

200 feet in length at forty feet from its top. In two places narrow spurs will be cut down thirty feet, and at the top of the pass there will be twenty feet taken off its height. Here, at an elevation of 5,222 feet, the third

Gowhatty, 64 miles.

Inspection Bungalow will be built. The two already adverted to are being built in the ordinary Assam style of thatched roof on posts, with bamboo mat walls and flooring, costing about Rupees 250 each; but such will not do at this elevation. Good rubble stone walls, chimneys, and planked flooring are required; and it is hoped that Government will sanction Rupees 1,500 for each Bungalow in the Cossyah Hills, as it is impossible for the Road Officers to live in tents during the greater part of the year without losing their health; and as a matter of mere economy it is cheaper to provide weather-tight accommodation than to have them frequently unfitted for duty through sickness.

21. After reaching the top of the Pass, which I will call that of Nongrimchilla, (for the village of that name is within  $2\frac{1}{2}$  miles,) we enter upon a country of long flat valleys and bare ridges grim and sterile in appearance during winter from the almost total absence of trees, but during spring and summer spread with a richly tinted carpet of wild flowers and berries. Where, too, the soil is best, hundreds of acres of potatoes, planted in the "lazy bed" fashion of the Irish peasant, shew its richness by their luxuriant growth, and prove the fitness of the climate for European crops. The cattle also, by their size and sleekness, evince the nutritious property of the natural grasses, and suggest speculation as to the weight and quality of the beef they might produce if stall-fed in winter with the turnip, which the potatoe land would undoubtedly supply. The Cossyah has an idea about manure, for he knows that the size and yield of his potatoes depend upon it; but the ordinary top-dressing he gives his land is burnt turf and rack after the manner, as I am told, of the Cornishmen.

22. The flat valley country extends with only

Gowhatty, 70 miles.

one interruption for ten miles in the direction of the line of road, and widens out to great breadth in the neighbourhood of the Village of Marpana, stretching up on the broad flank of Dinghai, which rolls up its massive out-line in the eastern horizon to a height only 370 feet less than Shillong. The one interruption alluded to is the second terrace of the Cossyah upper plateau, the rise from 5,200' to 5,600'. Except in temperature there is no difference between the two; therefore I have described them as one. This rise is arranged at a gradient of one foot in twenty-seven along the face of a hill presenting no special difficulties.

23. Under the Village of Marpana the road

Gowhatty, 70 miles.

shoots through a chasm formed by the river of that name, and this will constitute one of the most picturesque parts of the line. The river rushes from one flat valley to the next through a narrow opening between two ranges of cliffs, so narrow that it is not seen until the gorge is entered. From the cliff on the left bank the road will be cut, crossing the river where it turns sharply to the east by a bridge of about fifty feet span. It then gently descends at one foot in thirty-three to a highly cultivated valley, which it first touches and then slips over a low pass into another fine valley leading to the Kuksee Nullah. I feel con-

fident that this portion of the line will elicit approbation.

24. The Kuksee, lovely as a Devon Brook in its clear deep pools, and sparkling runs, its mossy

Gowhatty, 74 miles.

banks glowing with wild flowers and the bright strawberry, with here and there a rugged rock to force its calmer beauties into stronger contrast, bounds the last of the open valleys north of the "Wailing Waters," the rock-bound and terrible Oomeeam. Through oak copse, birch, and rhododendron the road gradually ascends to a pass 200 feet above the Kuksee, from which pass it winds down to the Oomeeam, crossing the river just before it is thrown into an abyss more than a 1,000 feet in depth. In the ascent a chasm of sixty feet has to be bridged, and in the descent about one quarter of a mile of very compact slate has to be cut through, otherwise no extraordinary difficulties occur.

25. From the Oomeeam the line ascends at first at a gradient of one foot in thirty along the very precipitous hill-side which slopes down to the river. Here the excavations will be heavy for about one mile, but the rock is not compact, and will offer no great impediment to the work-people.

Gowhatty, 81 miles.

Near the Village of Marbeegoo the line joins the present road from Moflong to Shillong about

Gowhatty, 86 miles.

three miles distant from the western boundary of the Station. At this point, after crossing a tributary of the Oomeeam, a fertile valley is followed up to the west flank of the Shillong Mountain, the gradient being one in fifty-five and the distance four miles.

26. Having described the line as far as Shillong, I will state what work has already been done between it and Gowhatty, the cost, and our immediate requirements; but in doing so here I beg to be understood as not in any way depreciating the project for the extension of the line of road to the Sylhet Plain. Without this extension the project would be but a half measure, and its great political and social advantages would remain undeveloped. Besides, I state the opinion of the Civil Authorities when I say that without a cart road to Sylhet it will be impossible to keep Shillong supplied with ordinary provisions.

27. As I write, it is just a year since I commenced exploring the country to the south of Gowhatty, and we now have the road (with the exception of a break of about ten miles) open

Indented for on the 27th July 1863, (vide this Office Nos. 1338 of 8th December 1863, and 1512 of 30th January 1864.)

for ponies or laden mules. Those ten miles will, I expect, be completed by the time this Report is in the hands of the Lieutenant-Governor.

There are narrow places where little could be done without blasting, and although long since applied for, neither tools nor powder have been sent from Calcutta.

28. We have suffered from the want of Officers and subordinates generally. Two Supervisors were sent up last year. Each returned to Bengal within a month of their arrival without having done one day's work on the road.

To Lieutenant Nuthall, the Executive Engineer of the Lower Assam Division, is due the progress of the work during the past year, and he undertook it when his hands were full of other important works. It will be remembered that laying out a hill road at fixed gradients in a country

covered with Assam jungle is no light work. The only subordinates he had to assist him were Assamese Sub-Overseers, all temporary, but one utterly uneducated and averse to work in the hills. This one was a notable exception. Sub-Overseer Khusnood was placed by me to open out, upon my lining out, sixteen miles of the road in the Cossyah Hills; he did this, quite unassisted, to my entire satisfaction at a cost of Rupees 2,000, including timber bridges over four considerable streams.

29. In August Lieutenant W. P. Tomkins, R. E., arrived as Assistant Engineer for the special charge of the road. He went to work at once with commendable zeal, and I look to his here laying the foundation of a useful and honorable career. If permitted to complete the road, as I originally proposed, it will be a noble work, and one of which those employed on it may be proud.

30. The want of labor has, of course, been a great source of trouble and anxiety. It is not solely the result of a paucity of inhabitants in the country; a good deal is due to the want of Assistants and fit subordinates, because had they been available work could have been commenced at many different places, drawing labor from the neighbourhood which could not be induced to move to more distant parts of the line.

31. The entire outlay up to the present date has been Rupees 14,655, and upwards of seventy miles are open to a minimum of five feet in width. This sum includes all expenses in surveying and laying out the first trial lines; in carefully surveying for Estimates thirty miles of finished bridle road; in a mile and a half of very heavy earthwork in the Gowhatti Plain, where the road passes through inundated ground. This earthwork is still incomplete. In building temporary timber and bamboo bridges over every stream; in clearing jungle for fifty feet on each side of road for twenty-five miles; in building one Inspection Bungalow and commencing another; in building numerous sheds for tools and putting coolies, and in carrying out provisions for them and Establishments generally.

• Upon the whole road the average cost has been close upon Rupees 200 per mile, which includes balances in hands of disbursers and contractors.

32. Considerable interruption to progress has been occasioned by the necessity of sending out from Gowhatti all requisite stores, provisions, and tools; carriage for such draws a number of laborers from road work, and disgusts many more who object to be made porters of. I am now in treaty (through the ever ready assistance of the Officiating Commissioner of Assam, Major Agnew) with a Bootan Chief for the purchase of a dozen mules, which will, I trust, be a source of relief to all parties. It may form the nucleus of a mule train, which will hereafter prove a great boon to the general public of Assam seeking health in the Cossyah Hills.

We are establishing shops for grain near all the Inspection Bungalows, so that, I trust, ere long the road may be travelled without inconvenience or hardship.

33. • Your letter No. 5891 of the 9th October last, authorized the opening out of the road to ten feet in width previous to submission of Estimates for a cart road twenty-four feet wide.

Opening out in soil has already commenced, but rockwork must await the receipt of tools and

powder. I beg forcibly to point out the loss of labor which opening the road by piecemeal entails. I would infinitely rather have an order to open out to twenty-four feet at once. For instance, a cliff has to be scarped first to a width of ten feet then to twenty-four. In the first operation the difficulty of obtaining the section will be nearly as great as in the second, and the two will cost nearly double what the second might have cost alone. Then again, in many places the width of the road is obtained by dry stone revetment walls, sometimes very heavy work. The opening from ten feet to twenty-four sweeps these away. In not a few places spurs and ridges have to be cut through. The labor is doubled by first having to excavate and carry away a section for ten feet and then again for twenty-four.

Stone, too, obtained from the excavations is not required for temporary timber bridges, and is therefore tumbled off the ten foot road. But when the time arrives to build the permanent bridges the same stone would be very valuable. Again, the day a portion of the twenty-four feet road is opened carts may at once ply on it, economising labor and providing carriage for building stone, lime, and girders for bridges, whereas a ten foot road is useless for anything but coolies or mules.

I am further of opinion that an Estimate may be equally correctly framed whenever the road is, as at present, sufficiently passable to be measured by chain, as when it is ten feet wide.

34. Under the above explanations I trust that I may now be permitted to prepare the Estimates for the twenty-four feet road, and commence upon it in anticipation of sanction. Instead of being deterred from urging this course by the paucity of labor hitherto experienced on the mere preliminary work, I feel confident that we shall obtain ten times the amount of labor when the full extent of the work is understood by the hillmen. Of course, I trust to Government giving me a sufficient number of subordinates for so large an undertaking.

35. I will now describe the line I have selected for the descent from Shillong to the Sylhet Plain, which, for reasons stated, differs somewhat from the line I examined in 1862. The highest point reached by the road at Shillong is by aneroid 6,088 feet above sea level. The Sylhet Plain is by the same instrument fifty-two feet. The bare required for such descent at a continued gradient of three feet in 100 is thirty-six miles nearly. The intervening Valley of the Bogopance and the necessity of keeping as near as possible to the watershed line, to avoid a mass of difficulties which the well-known precipitous walls lining the southern face of the Cossyah range presents, obliged me to increase this base to fifty-three miles. But this is no drawback to the excellence of the line, because an unbroken ascent of three feet in a 100 for so great a distance would have been very severe upon draught cattle, and the selected line in no place proceeds very much out of its true direction.

36. The difficulty was to find a base of sufficient length which did not run us into the great natural bastions of sandstone abovementioned, and which would not necessitate zigzags, these most objectionable make-shifts for avoiding difficulties in hill roads. This was the objection I found to the line explored in 1862, *vide* paragraph 5 of letter No. 806 of 9th December 1862, when I came to lay it out.

I first of all examined two lines running through Cherra Poonjee, (which Station 1 should have liked to have brought on to the line of road,) one to the westward by Chelak, the other taking the line projected by Lieutenant Yule (now Colonel Yule, C. B.) in 1842, for the incline from the coal mines to the plain. Both I found led through very difficult ground, and would have entailed many zigzags. Besides, Cherra stands immediately overlooking the plains at a height of 4,400 feet above them; such a difference of level would have required a base of at least twenty-two miles, whereas the distance by footpath is not above eight. This would not only have been a highly unpopular feature in the road, but would in reality have considerably increased the distance from Shillong to the plains, as the country between Shillong and Cherra undulates too steeply for a cart road upon the line of the present path, and this would have necessitated several inclines quite out of the true direction, thereby considerably lengthening the distance beyond what it is at present.

37. I then tried the line which I explored in 1862 through Lailankhote, descending from the gorge by the stream which flows southward towards Ponduah, but this led through such ground that for miles I could not obtain even footing. To explore the line for a hill road when the glens and ridges are covered with jungle, and to lay it out at a restricted gradient, are two such different operations that it is almost impossible to estimate by mere exploration either distances or difficulties.

38. I lastly tried a line through Lailankhote down the long spur passing Nonkredem, the residence of the Rajah of Khyrim, and abutting on the Sylhet Plain at Lukhet. Here I found a possible base line through a country generally favorable (with the exception of four miles near Nonkredem) reaching the plain within twenty miles of the Station of Sylhet.

In my letter above quoted I suggested that the southern terminus of the road should be at Chattuck, because that was the highest point on the Soormah that steamers could reach at all seasons of the year; but it has since been pointed out to me that Chattuck is no base from which supplies for Shillong could be drawn, and that unless easy communication is established with Sylhet, there will be great risk of the troops and residents at Shillong being hard-pressed for provisions. Again, it has occurred to me that, as Shillong is looked to as the great sanatorium for the hundreds of European Planters who will ere long overspread Cachar and Sylhet, it is but right, provided there is no fatal objection, that the southern approach to it should be from a central point, such as the Town of Sylhet. Also the approach to Chattuck from the north is through an inundated country barren of cultivation, whereas that to Sylhet is, with the exception of four miles, cultivated, and only inundated to a more moderate depth. Further, if communication with the Chattuck River is thought to be a matter of necessity, a branch road to Companyganje from the direct Sylhet line would be a simple matter. In my Report on the Sylhet and Cachar Road under preparation, I will revert to this subject when suggesting a further extension of first class lines of communication in the Sylhet and Mymensing Districts.

39. In my letter of the 9th December 1862 I was led into error as to the probable distance from

Gowhatty to Chattuck, which I stated as about 104 miles. The almost impenetrable mass of jungle which covered a portion of the hills between the Cossyah range and Gowhatty prevented my seeing much of the sinuosity of their contour, and my endeavors to reduce the general gradient to a rate not exceeding one in thirty have considerably added to the distance, which will now be, from Gowhatty to Sylhet, 154 miles. The distance by the old mountain road *via* Cherra Poonjee is 142 miles. Considering that the first is to be a cart road with no gradient exceeding one in twenty-five, and that the second was laid out without reference to gradients at all, except that at which a pony could climb, the result is more favorable than that ordinarily obtained in hill roads.

40. I will now examine, in detail, the line adopted from Shillong to Sylhet, of which about four miles in the Valley of the Bogapanee is open to eight feet in width, and the rest only laid out. The construction of a bridge road is delayed for want of a subordinate to take charge of it, and I fear if one is not posted shortly as asked for in my letter No. 762 of the 21st September last, that all the work of laying out will be lost.

41. Leaving the western shoulder of Shillong at 6,088 feet, the descent of Gowhatty, 86 miles. 600 feet to the torrent of the Bogapanee is effected at a gradient of one foot in thirty-three for four miles and nearly level for two. The hills are bare and covered with short grass. The geological formation presents few difficulties. This is the chief iron region of the Cossyah Hills, and large quantities are continually being taken to Lukhet to barter for grain and the produce of the plains. The projected road will assist this traffic greatly.

The erection of a stone bridge over the Bogapanee with timber platform was commenced last year, but a very great rise in the river swept away the centre pier before it was half built up, and a fresh project, avoiding any intermediate pier, is now under preparation.

Four miles further down this river an iron suspension bridge was built, about 1844, but was swept away by an extraordinary rise in the river six years afterwards.

I believe that an entirely stone bridge of one opening of ninety feet span will prove the best structure for this very troublesome torrent.

42. After a mile and a half of ascent through huge boulders of granite the road reaches Lailankhote, where it crosses the Cherra Poonjee and Jowai Road. The ascent is easy, and with proper blasting tools the formation of the roadway will not be difficult. From the Lailankhote plateau commences the steady descent to the Sylhet Plain, unbroken, except by a few level portions, and it is between Lailankhote and Nonkredem where the only real difficulties of the line are met with. The hill sides are there very steep, and the rock lies near the surface. It is, according to Oldham, of the metamorphic series, and is decidedly difficult to work.

43. The first difficulties are caused by a sudden break or wall in the spur of 460 feet in depth. This obliges us to cut the road, not of the steep hill side facing the east, which is exceedingly rocky and precipitous. There is no other available



line, and so we must face it. After reaching the bottom of this wall at an obligatory point called Roloo, we skirt a peculiarly isolated hill and pass on the water-shed line following it to Nonkredem. In several places it is nothing but rock forming narrow sharp ridges, at present broad enough only for a very bad mountain path. These sharp ridges will have to be cut down until a sufficiency of width is obtained for the road. As stated in my

\* 9th September 1882.

letter above quoted,\* it is scarcely possible to have all this rock excavation effected without the assistance of a Company of Sappers, or at least a body of men accustomed to blasting operations. We have taught a few men here and there; but I can testify, from long experience in such operations, that a mass of excavation in rock can only be successfully accomplished by the concentration of a considerable force worked in a systematic manner. This cannot be obtained with such laborers as the Cossyahs, who, although possessing a wonderful talent for engineering, will not remain regularly at work, and consequently cannot be depended upon in a long and tedious operation.

44. After passing Nonkredem we return to the sandstone for nation, affording easy ground for a hill road passing over grass slopes broken here and there with oak woods. On the opposite hill Cherra Poonjee can be easily seen, but between it and the line lies a tremendous chasm, eight miles in width and 4,000 feet in depth.

The same easy ground extends the whole way down till within a 1,000 feet above the Sylhet Plains. Occasionally rocks are met with, but no extensive cliffs. The hill sides are generally pretty clear of jungle, and nothing could be more

Gowhatty, 114 miles.

See Oldham's Geology of Khasia Hills, page 86.

favorable for a line of hill road. At Tunginath, 4,400 feet above the sea level, the coal seams described by Mr. Oldham are passed. The distance to them by road from the plains will be probably twenty-five miles.

45. At 1,000 feet above the plains commence dense plantations of Areca, Jack, and Orange trees, for which the south face of the Cossyah and Jynteah Hills is famous. They grow on very little depth of soil and over rough rocky ground. The road

Gowhatty, 137 miles.

will be expensive throughout these five miles of descent, but not more than ordinarily so in hill road work. There will be a good deal to pay for compensation for damage done to the plantations, probably about Rupees 3,000 per mile, or Rupees 15,000 in all.

46. It may be well here, where my description of the hill portion of the road ceases, to state what my opinions are now as to the mileage cost of a twenty-four feet road across from plain to plain. I stated formerly that it would be about Rupees 4,500 per mile, but that was considered by you an under-estimate, and you preferred taking Rupees 7,000 per mile. Assuming as the rates for excavation, Rupees 5 per 1,000 in soil, Rupees 8 in stony ground reducible with pick-axe and crowbar, Rupees 15 in rock and slate, where frequent blasting will be necessary, I estimate that there will be—

56 Miles of the first.  
67 " " second.  
7 " " third.

The section of the first class will give about 2,64,000 cubic feet per mile. The section of the second about 6,33,000 per mile. The section of the third about 12,67,000 per mile. From this we have—

	Number of miles.	Cubic Feet per mile.	Rate per 1,000.	Cost.
First Class ...	56	2,64,000	Rs. 5 =	Rs. 73,920
Second Class..	67	6,33,000	" 8 =	" 3,89,288
Third Class ...	7	12,67,000	" 15 =	" 1,15,000
400 Masonry Culverts, at Rs. 500 each				" 2,00,000

(Stone everywhere procurable.)

750 Running feet of stone and iron bridges, at Rupees 120 per foot ... Rs. 90,000

Probable cost of road within the hills ... Rs. 8,18,208.

To this has to be added twenty miles of road in Sylhet Plain, at Rupees 4,000 per mile ... 80,000

And 700 feet of masonry and iron bridges, provided the Peine and Gwine Rivers are bridged, at Rupees 120 per running foot ... 84,000

Probable total cost of road... Rs. 9,82,208, or about Rupees 6,000 per mile.

About one-half the road may hereafter require to be metalled.

47. I have only now to describe the portion of the line in the Sylhet Plain. It is not generally more than fifty feet above the level of the sea, and is consequently liable to inundation from the backing up of the rivers during the rainy season. This is more especially the case immediately under the hills where the elevation is still less than on the banks of the large rivers that intersect the valley, the Soormah and Kooshegarah. These, by the deposit of silt, are being gradually raised above the normal level.

48. In any case, then, a road communicating between the hills and any town on these rivers must pass through a certain portion of low country. The direct line from Nya Haut, where the Shillong Road will reach the plain to Sylhet, will pass through about four miles of inundated country on either side of the Peine River. After doing so, it reaches a highly cultivated rice country passing near Durgam and Augajoor to the Salooke Ghaut on the Gwine or Chinga Khall. From the Ghaut a very heavy bunded road exists to Sylhet, six

Gowhatty, 157 miles.

and a half miles distant. It is also bridged, but from the employment of bad material the bridges are falling into decay. I propose having both the road and bridges put into better order. They have not hitherto been under charge of the Department of Public Works. The Peine and Gwine Rivers will each require bridges of 300 feet in length, divided into bays of sixty feet. Wrought iron girders upon screw piles will be most suitable.

49. In concluding this Report, I may state that from what I now know of the Cossyahs I believe that this great work might be constructed within three years. Bringing into easy communication Assam and Sylhet, whilst at the same time it opens out a sanatorium for each, and extends the area of rich cultivable land to the European settler, it affords the best security against future.



Jynteah outbreaks, and appears in all its bearings to be a most desirable undertaking.

From LIEUTENANT-COLONEL J. P. BEADLE, E. F., Secretary to the Government of Bengal, in the Public Works Department, to the Secretary to the Government of India, Public Works Department,—(No. 2502, dated the 16th May 1864.)

THE Government of India, in Proceedings No. 465, dated 30th January 1864, was pleased to approve generally of the proposal to construct two great lines of road in the Province of Assam.

A highway along the Valley of the Berham-pooter River to communicate with the North-Eastern Districts of Bengal, and a road across the Cossyah Hills connecting Gowhatty, the principal Station of Assam, with the Station of Shillong, and thence by the Jynteah Hills with the River Soornah, in Sylhet, which is navigable for steamers.

2. Progress was sanctioned for opening out the line of hill road from Shillong to Gowhatty limited to an expenditure of Rupees 35,000, and from Shillong to the River Soornah on the Sylhet side at an expense of Rupees 5,000.

3. The accompanying Inspection Report of Major D. Briggs, Superintendent of Assam, reports the extent to which this sanction had been worked upon in February last.

4. The Report is a very interesting one, but it shews clearly that the undertaking is certain to cost a large sum of money, and that the work should not be further proceeded with without an accurate section and survey and a detailed Estimate.

5. His Honor the Lieutenant-Governor attaches the greatest importance to the construction of this road with easy gradients for wheeled carriage, and Major Briggs quite expresses the Lieutenant-Governor's opinions when he describes it as "bringing into easy communication Assam and Sylhet, whilst at the same time it opens out a sanatorium for each and extends the area of rich cultivable land to the European settler, it affords the best security against future Jynteah outbreaks, and appears in all its bearings to be a most desirable undertaking."

6. But it was quite clear also that the work is of sufficient importance to be made at once a separate executive charge, and when Captain Davies' services were made available, he was directed to proceed to Gowhatty and report himself to Major Briggs for employment on the survey and construction of this road and of the new Station of Shillong; and he left this fully equipped with surveying instruments and with some knowledge of the Division and duties to be performed.

7. Captain Davies' experience in the formation of hill roads in the Punjab and his recorded energy pointed him out as a proper Officer to place in charge of the Shillong Road Division.

8. Major D. Briggs has been instructed that the first thing to be done is to obtain an accurate section and survey, with a detailed Estimate, for the construction of the road from Gowhatty to Shillong, and that until this Estimate is submitted and passed, it were better not to expend any more money under the mileage sanction given by the Government of India, the total of which is not on any account to be exceeded.

9. The Lieutenant-Governor has desired that attention should be at first concentrated on this portion of the road, and the Superintendent has been informed that an Estimate may be submitted

for opening out a bridle road from Shillong to the old road from Sylhet, so that the communication with Sylhet may be maintained.

From LIEUTENANT-COLONEL J. P. BEADLE, E. F., Secretary to the Government of Bengal, in the Public Works Department, to MAJOR D. BRIGGS Superintendent of Works in Assam,—(No. 2501, dated the 16th May 1864.)

Your interesting Report, No. 1702 of the 18th February 1864, has been submitted to the Government of India with a strong recommendation for the formation of a new Division for the Shillong Station and road.

2. Captain Davies has been nominated by the Lieutenant-Governor to the charge of this Division, and went up to Gowhatty fully equipped for survey duties.

3. As respects the road from Gowhatty to Shillong the first thing to be done, now that the trace has been opened out, is to verify your aneroidal observations with the correct test which a proper levelling instrument will afford. An accurate section of this portion of the road should be submitted as soon as possible, and until it is done, it were better not to expend any more money in opening out the line of road under the mileage sanction given by the Government of India, the total of which is not on any account to be exceeded.

4. When a correct section and survey shall have been made, an Estimate for completing the road must be prepared; and such a detailed properly drawn up Estimate as can be submitted to the Government of India for sanction.

5. The Lieutenant-Governor would wish for the present that attention should be concentrated on the section of road connecting the new Station of Shillong with Gowhatty. The shelter so urgently required for the Officers employed on this road may be constructed as recommended in your Report; but there should be no delay in furnishing an Estimate, with Plans, for the Bungalows which are to cost Rupees (1,500) one thousand and five hundred each. The Bungalows to be constructed for Rupees 250 each may be estimated simply as for so many superficial feet of temporary Bungalow, illustrating by a sketch plan the accommodation and construction.

6. Your description of the road from Gowhatty to Shillong shews that it is a much more formidable work than was anticipated, and the experience gained in the construction of the Darjeeling Hill Road has proved the necessity of great caution in proceeding with such works. The further experience obtained of the line of country since your first inspection and report has already raised the Estimate for a road from Gowhatty *via* Shillong to the Plains of Sylhet from 4½ lakhs to nearly 10 lakhs of Rupees; and under the rules, which are stringently enforced, no expenditure can be sanctioned in forming the road until a detailed Estimate based on an accurate section is submitted and passed. The road, where blasting is required, need not be made wider than twenty feet, which is sufficient for the drain and parapet wall, which are required for a hill road, leaving an available space for traffic of sixteen feet.

7. Captain Davies, with the Assistant Engineers attached to the works, should therefore proceed with all diligence to complete the survey, and to collect the information required to enable him to prepare the Plans and Estimate for the section of road from Gowhatty as far as Shillong.

8. The continuation of the road and its completion to the Plains of Sylhet is another matter, and I am instructed to say that the Lieutenant-Governor is not at present prepared to give up your first plan of making Chattuck the terminal point of the road, for which very good reasons were given in your first Report.

9. For the present it would be well, perhaps, to open out a bridle road from the new Hill Station to the old road from Sylhet, and an Estimate for doing this may also be submitted.

From MAJOR D. BRIGGS, Superintendent of Works in Assam, to the Chief Engineer, Bengal,—(No. 310, dated the 25th May 1864.)

I HAVE the honor to submit a Map, a sheet of Sections, and an Estimate drawn up by the Executive Engineer, Lower Assam Division, of the Choygong section of the Assam Trunk Road, completing, with the exception of bridges, the Estimates for that work, from Gowhatty to Choygong, twenty-six miles, in the Goalparah direction. The Estimate is only for earthwork for reasons given in the Report, and amounts to Rupees 59,112, or about Rupees 3,700 per mile.

2. The line adopted is that sketched out in my first Report on the Assam Trunk Road submitted in May 1863; and, although with the highest flood line shewn in the Plan, it looks ominously low, yet it is the best obtainable, and, for the reasons given in that Report, I entertain no fears of its stability. In that Report I said that the drainage of the Assam valley ebbs and flows, as the Berhampooter rises to its flood level and falls; so that a bund road running up and down the valley, parallel to the river, will serve to restrain the volume of water otherwise thrown over the country, and the return ebb will be correspondingly diminished. This assists in the reduction of waterway in bridges.

3. The great height of raising according to the Executive Engineer's sections, allowing the roadway to be two feet above highest flood level, is 12.14 feet, and that only for a distance of 200 feet. There are only 2,700 running feet, of raising ten feet high or above it.

4. In depressions where it is doubtful whether bridges will be requisite, it is proposed to construct an embankment half the width of the roadway, in order to test the necessity of a bridge.

5. The Executive Engineer defers his Estimate for bridges until the result of this season's rains upon the earthwork is known. But I would recommend sanction to the collection of building material along the line as soon as the next working season commences.

6. In my preliminary Report on the Trunk Road, I considered that besides culverts a girder bridge across the Kulbog, of fifty feet span, and two bridges, each of two openings, of sixty feet each, over the two channels of the Koolsee (called in Mr. Nuthall's Report the Chowrie and Kylas Nuddees) would suffice for this section of the line.

7. It is very difficult to say what these two channels require. When united within the Cosyah Hills, previous to debouching on the plain, they form the Burrapanee River, which, having

its rise to the east of Nunclow, drains about 700 square miles. On reaching the flat valley of Assam, the waters of this river spread out into vast lakes, which discharge into the Berhampooter by means of the two channels, of which sections are given by the Executive Engineer in accompanying sheet of drawings. But to shew how little information can, in this instance, be gained from mere sections, I beg to direct your attention to the sections of the eastern channel, called the Chowrie. The area of waterway at the site of crossing during the cold season appears to be 1,306 feet, whilst half a mile below it was only 900, and three quarters of a mile above only 738 feet. The fall in the country is only 2.20 feet in one and a quarter mile. But the fall between the surfaces of the stream at the upper and lower Stations is 5.82 feet, and the fall of the bed 5.72. It is a remarkable fact that the bed of the nullah at site of bridge is 6.08 feet lower than at the Station half a mile further down the river.

8. In the western channel, called in Mr. Nuthall's Map the Kylas Nuddee, the lowest section shows an area of about five-sixth less than the one taken half a mile above it. There is absolutely a rise in the bed of the stream of 0.20 feet between the upper and centre sections, and a fall from the upper to the lower of 4.04 feet. In fact, nothing can be determined about these rivers until the embanked road through the country is made.

9. The style of the bridge adopted on the Singarun River at Toposi, in the First Division, Grand Trunk Road, would be very suitable for these shallow streams.

#### REPORT.

THE present project is to complete an embanked road from Gowhatty to Choygong, about twenty-three and a half miles, across a portion of the country so heavily inundated during the floods of the Berhampooter that it is at present quite impassable, except during the dry season, except by boat. Of this twenty-three and a half miles the first six and a half miles have been already surveyed and estimated for, and progress has been made during the last three seasons in the portion known as four miles west of Gowhatty: an intermediate portion between this and Gowhatty having also been estimated for, but work not yet commenced in consequence of the Estimate not having yet received sanction. The seventeen miles included in the present project will complete the road thus far. There is but little to be said in this report on the work now proposed. The line has been selected with care and was determined by the fact of the banks of the Berhampooter being the highest part of the country, the general surface of the country sloping inwards from them towards the hills, under which, and at irregular intermediate distances, exist large marshes at all times of the year, which in the rainy season become perfect lakes. These it was necessary to avoid, and the road was thus run passing the villages bordering the Berhampooter. The above applies as far as the fourteenth mile from Gowhatty, where a break occurs in this general style of formation, and the banks of the Berhampooter become irregular, and in many places so low as to be overtopped by the floods. A backbone as

it were, or ridge running across diagonally in a south-west direction, only broken in one place where the floods have apparently forced their way through at the Bagmara Bheel between the sixteenth and seventeenth miles, has here been taken advantage of and followed up to the twenty-second mile, where it merges into the low lands of the Churre Nuddee. Beyond this to Choygong the road has to be forced through heavily inundated land, which there is no avoiding. A portion of this from the twenty-third towards the twenty-fourth mile was formerly partially embanked, but never sufficiently high to overtop the floods which have thus gradually broken into it. In the present Estimate, however, no allowance has been made for this old work, as its ditches are so close to the foot of the embankment that they will require to be re-filled, which will entail as much labor as will be saved by the embankment previously formed from them.

As regards bridging no project is yet offered. Between the ninth and ten miles exists an overflow of the floods from the Berhampooter. It remains to be proved whether it will be advisable to bridge to allow this to cross the road, or to leave it to drain itself off after the floods subside. The embankment has been completed through this season, so that a finite result will be arrived at before next working season.

Beyond this merely small culverts will be required at intervals to pass off the surface drainage of the villages and lands between the road and river. The necessity of these can be more fully and satisfactorily determined by examination than calculation on grounds so continuously inundated as is this at certain seasons. The above remarks apply to all culverts for surface drainage alone throughout the line. Besides these, however, are three actual water-courses, which will require bridges of larger dimensions. The first, the Kulbagjun, is an inlet from the Berhampooter, having the same character as the Khuna Nuddee in the fourth mile west of Gowhatty, for the bridging of which so many references have been made. Whatever is eventually decided regarding the Khuna Bridge, will necessarily form the rule for the design for that over the Kulbag, pending which, I imagine, it would be unadvisable to submit any design.

The other two are branches of the Burapani, which flows from the Cossyah Hills and bifurcates after leaving the hills. I have provided all the usual data for the calculations of the necessary waterway of these bridges; but would offer my opinion that it is improbable, considering the small section these actual streams have, in comparison with the enormous extent of inundation around them, that any of the usual calculations would give an accurate result. Though my sections have a considerable fall in the beds of these rivers, yet such falls are merely local, as may be seen from the general run of the country in longitudinal section.

The cross sections also vary greatly, and frequently the course of the rivers is altogether lost in the adjoining swamps. I believe that more certain data, than shewn in present cross sections, &c., will be obtained in the completion of the embankments next season.

From LIEUTENANT-COLONEL J. F. BEADLE, B. E., Secretary to the Government of Bengal, in the Public Works Department, to the Secretary to the Government of India, in the Public Works Department,—(No. 3603, dated the 21st July 1864.)

REFERRING to the orders marginally noted, on the subject of the Assam Trunk Road, I am directed by the Lieutenant-Governor to submit, for the consideration and orders of the Government of India, the accompanying Estimate\* as revised in this Office, which provides for the earthwork of that portion of the Trunk Road from a point six and a half miles west of Gowhatty to Choygong, a Thannah Station of some importance seventeen miles further on, at a cost of Rupees 56,498; the road for the first portion out of Gowhatty being nearly completed under a sanctioned Estimate.

2. The nature of the work proposed, and the description of the country through which the road will pass, is described in the Report attached to the Estimate.

3. I am to explain, however, that the greater part of the inundations referred to in the opening of the Report is the spill flood of the Berhampooter River, which will be shut out from the country by the proposed road which will be raised to a height of two feet above the flood level of that river. But it is impossible at present to state, with any pretence of accuracy, the waterway that will be required to pass off the drainage of the country to the south of the road. The Superintendent states, in submitting the Estimate for this portion of road, that the floods in the Assam Valley follow the flood level of the Berhampooter as it rises and falls, so that a raised embanked road, more or less parallel to the river, will serve to restrain the volume of water otherwise thrown over the country, and the return flow will be correspondingly diminished.

4. In doubtful places, where it appears probable that waterway may be required, only half the width of embankment will be formed in the first instance, with a view to testing practically the extent of bridging required.

5. I am to add that the Chief Engineer, in recommending that sanction should be given to the Estimate, as now submitted, is aware that the project is far from being as complete as it should be. But there is no prospect of obtaining at present a more complete and reliable Estimate or project, and funds and labor for the work are available. The working season is so short in Assam that advantage must be taken of it from the commencement. There is no doubt of the necessity for the work forming, as it does, a portion of the Assam Trunk Road; and it appears to the Lieutenant-Governor to be in every way desirable that the Estimate, which is only for earthwork, should be accepted, the work having been placed in progress, as shewn in item No. 103 of the Budget of the year.

6. The Survey received from the Superintendent of Works in Assam, and a copy of a Map of the country on a small scale as prepared in this Office, are herewith forwarded.



From COLONEL R. STRACHEY, R. E., Secretary to the Government of India in the Public Works Department, to the Secretary to the Government of Bengal in the Public Works Department,—(No. 1166, dated Simla, the 27th August 1864.)

In reply to your letter No. 3603, dated the 21st July 1864, I am directed to communicate the sanction of the Governor General in Council to the Estimate, therewith submitted, amounting to Rupees 56,490, for the earthwork of seventeen miles of the Assam Trunk Road, from a point eight and a half miles west of Gowhatty to Choygong Thannah. I am to request, however, that, in sending up the complete Estimates for this portion of the road, attention may be drawn to this Estimate, or to the expenditure actually incurred on the earthwork, so that the Government of India may have before it a complete view of the cost of the works.

From MAJOR D. BRIGGS, Superintendent of Works in Assam, to the Chief Engineer, Bengal,—(No. 252, dated the 20th May 1864.)

As directed in the last paragraph of your letter No. 5891 of the 9th October 1863, I have the honor to forward an Abstract Estimate, by Captain Davies, Executive Engineer, Fourth Class, for opening the Gowhatty and Shillong Road to a width of ten feet, amounting to Rupees 69,464.

2. This is nearly double the amount which I anticipated being necessary for a ten feet road in my No. 762 of the 21st September last, and it is necessary that I explain the causes of difference.

3. First, as reported in my letter No. 1702 of the 18th February last, the length of road has increased on opening it from seventy miles (my first Estimate) to eighty-six, which hereafter may be reduced to eighty-one by cutting off salients and filling in re-entering angles. I can offer no other explanation of this difference than the difficulty, in a mountainous country covered with heavy jungle, of judging the length to which the adoption of a fixed maximum gradient may carry a road.

4. Second, in my first Sketch Estimate I did not contemplate spending Rupees 10,000 on embankments in the plains, which rather came into the grander project of a twenty-four feet road. However, it was found that without these embankments over inundated ground travellers would have to make detours off the selected line, and their construction is so much to the credit of the future twenty-four feet road.

5. Third, my Sketch Estimate did not include Rupees 1,800 for Overseers' Bungalows, which I have since seen the necessity of building. In a wild country, subject to much bad weather, huts are not safe residences for European Officers or Overseers.

6. Fourth, since my Estimate went in, it has been necessary to raise laborers' wages from three to four annas per idah, adding one-fourth to the probable cost of the works.

7. The last of these causes adds 4) 35,000, or Rupees 8,750 to the first Sketch Estimate. The third adds Rupees 1,800; the second adds Rupees 10,000; the first adds Rupees  $25000 \times 16$ , or Rupees 10,032. In all Rupees 30,582.

This, added to the amount of first Sketch Estimate, gives a total of Rupees 65,582, which is nearly the sum now asked for.

8. Up to date the work has cost Rupees 23,000, and it is generally passable for a laden mule. Rupees 40,000 are granted in the present year's Budget, but Rupees 46,000 are required.

9. The survey has progressed sixty miles, and the longitudinal and cross section seven miles. It is expected that the Estimates for a twenty-four feet road will be ready for submission by October next.

From CAPTAIN F. J. DAVIES, Executive Engineer, Shillong Division, to MAJOR D. BRIGGS, Superintendent of Works in Assam,—(No. 18, dated the 18th May 1864.)

IN accordance with instructions contained in your Memorandum No. 162, dated 15th instant, I have the honor to forward an abstract Estimate for the ten feet road sanctioned, and now under construction between Gowhatty and Shillong, which I solicit you will recommend for sanction, pending the submission of the Estimate for the twenty-four feet road, for which surveys and sections are now being made. Sixty miles have already been surveyed by my Assistant, Lieutenant Tomkins, and he is now proceeding to finish the survey and take a line of levels and cross sections along the whole line.

2. The line has proved somewhat longer than was anticipated, eighty-seven miles to the junction of Rowlett's Road (one branch of which, six miles long, leads to Shillong, another of three miles to Mofiong.) Of this the first two miles is opened out to the full width for a ten feet road, and I hope to reduce the remainder by shortening the inflections, where the gradient will admit of it, about four miles more, leaving eighty-one miles to open out.

3. It is proposed to erect, in accordance with your orders, Bungalows at the Oomer Nuddee, twenty-third mile, (nearly completed); at Palhar, forty-seventh mile; and at Nongrum Chilla, seventy-fifth mile, out of the amount sanctioned. The two former to be erected on posts, with raised mahan floors, mat or reed walls, and grass roofs; the latter, being at a much higher elevation, to be built of kutcha-pucka masonry, with fire-places.

4. This Estimate does not include the expenditure of Rupees 6,000 for which sanction was given in Secretary to Government's letter No. 5891, dated 9th October 1863, for preliminary expenditure in surveying and tracing line.

From LIEUTENANT-COLONEL J. P. BEADLE, R. E., Secretary to the Government of Bengal in the Public Works Department, to the Secretary to the Government of India in the Public Works Department,—(No. 2946, dated the 10th June 1864.)

IN continuation of my letter No. 2502 of the 16th ultimo, I am directed by the Lieutenant-Governor to submit the accompanying Estimate,

\* No. 18 of 18th ultimo. \* together with a copy of a letter\* from Captain Davies, Executive Engineer at Shillong, to the address of the Superintendent of Works, in Assam, on the subject of the road now under construction between Gowhatty and Shillong.

2. In the letter from this Office No. 3413, dated the 10th June 1863, sanction was solicited to an expenditure of Rupees (1,000) one thousand per mile for opening out this line of communication as a "serviceable track in the first instance," and the Government of India was informed by a

subsequent communication, No. 5892 of the 9th October last, that the Lieutenant-Governor had authorized the commencement of work; the road to have a width of ten feet, with a gradient not exceeding one in twenty-five, to be provided with rough timber bridges, and the jungle to be cleared for fifty feet on both sides; and that the sum of Rupees (35,000) thirty-five thousand had been appropriated for the work to be expended during 1863-64.

3. The Government of India, in orders No. 465 of the 30th January last, was pleased to confirm the authority thus given by the Lieutenant-Governor to the expenditure of Rupees 35,000 on the work in the past year; and my late letter, No. 2502 of the 16th ultimo, with enclosure, will have shewn the progress made up to February last.

4. The Estimate now submitted amounts to Rupees 69,464, and shews that, whilst a sum of Rupees 23,000 was expended on the work to the close of last year, a further sum of Rupees 40,000 has been provided in the Budget Estimate for this year.

5. The Estimate includes all the work and expenditure necessary for opening out the road for a width of ten feet, with timber bridges. It has been prepared by Captain Davies, who has been recently appointed to the charge of this road, and the work is in active progress. Under these circumstances, and with advertence to the detailed Inspection Report of Major Briggs previously submitted, I am to request that the sanction of the Government of India may be given to the amount of this Estimate, on the understanding that nothing further will be attempted than is provided for in the Estimate, pending the orders of the Government of India on the detailed surveys, sections, and complete Estimate, for the formation of a carriage road, twenty-four feet wide, which the Superintendent of Works reports, under date the 20th ultimo, will be ready for submission by October next.

6. I am to add that the road is reported to be at present "generally passable for laden mules."

Memorandum from MAJOR D. BRIGGS, Superintendent of Works in Assam, to the Chief Engineer, Bengal,—  
(No. 342, dated the 30th May 1864.)

WITH reference to the 7th paragraph of the Government of Bengal, Public Works Department letter No. 5891 of the 9th October last, forwards the accompanying letter, No. 162 of 23rd instant, from Lieutenant Heywood, Executive Engineer, Sylhet Division, in which he gives an approximate Estimate, amounting to Rupees 9,500, for constructing the bridle path from Shillong to Sylhet Plains, for which a sum of Rupees 5,000 was sanctioned by Government in the letter above quoted. The undersigned begs to state that the amount sanctioned is found inadequate to cover the expense which would be incurred in constructing a useful mule track, and therefore requests that the Chief Engineer will urge upon Government the sanctioning of the full amount of the Executive Engineer's Estimate. The Superintendent will take care that, in the event of the cost being likely to be exceeded, prompt measures will be taken.

From LIEUTENANT J. M. HEYWOOD, R. E., Officiating Executive Engineer, Sylhet Division, to MAJOR D. BRIGGS, Superintendent of Works, Assam Circle,—  
(No. 162, dated the 23rd May 1864.)

WITH reference to your Memorandum, No. 161 of the 13th instant, calling for an abstract estimate for a bridle path from Shillong to the Sylhet Plains. I have the honor to forward the same, made out as well as I can calculate. As several portions of the line are not even laid out, though the whole has been traversed, it is impossible to give an absolutely correct estimate. Comparing the height of Tanganath, as determined by you, with the Aneroid Barometer 4,200 feet above Lacat, with the trigonometrical height 4448.39, it would appear that Lacat is 188.39 above the level of the sea.

The following Table will therefore give the height of the various fixed points above the level of the sea.—

Name of Place.	Height above level of Sea.	Height above Lacat.	Probable length of road between.
Lacat	488		
1st fixed point	810	630	3 miles.
2nd fixed point	1,278	1,090	2 1/2 "
Point opposite Koondir	2,518	2,230	5 1/2 "
Neck at the head of the Sawalullung River	3,098	2,840	3 "
Fixed point near Sowah	3,768	3,480	4 "
Point at the head of a stream	4,268	4,080	4 1/2 "
Edge of cliff to west of Nonkraden	4,888	4,700	3 "
Ditto ditto east of Nonkraden	5,058	4,870	1 1/2 "
Point called Killor	5,308	5,120	2 "
Lailangkote	5,808	5,680	5 "
Total			33 miles.

The height of Lailangkote above the level of the sea, according to Professor Oldham, is 5,703, so that the heights as given in the Table are not far from the truth. The gradient ordered to be adopted being one in twenty-five; the length of the road from Lailangkote to Lacat would be nearly twenty-seven miles, but in many places the fixed points are such that a slighter gradient is necessary. Between Lacat and the neck at the head of the Sawalullung River every inch of ground has to be taken advantage of, and the full gradient is given. Beyond this part, the Village of Sowah, up to the point noted as at the head of a stream near the Nonkraden and Lacat road, the gradient must be in many places much more gradual, and I have accordingly allowed for a slope of one in thirty-four. From this last point to the edge of the cliff to the east of Nonkraden the gradient of one in twenty-five almost exactly strikes the fixed points. The rest of the road into Lailangkote will be considerably under the full gradient in most places. The cost of the road will vary so much in different parts, that it is hardly possible to do any thing else than give an approximation.

Work is being carried on at four different places—

Near Lailangkote at 5,308 feet above the level of the sea.

Near Nonkraden at 4,888 feet above the level of the sea.

Near Sowah at 3,768 feet above the level of the sea.

Near Koondir at 2,518 feet above the level of the sea.

The cost of opening out the road to six feet at the four places is per mile as follows:—

On the Lailangkote Section ...	Rs.	286
Ditto Nonkraden .....	"	275
Ditto Sowah .....	"	201
Ditto Koondir .....	"	177
Mean ...	Rs.	235 nearly.

This is taken from some of the daily reports, but the expense incurred up to the end of April shews an average of 345 Rupees per mile, owing to the extreme difficulty experienced in the Lailangkote Section, where the average per mile was in March 408 Rupees.

I therefore calculate the cost of the entire road as follows:—

Lacat to the edge of cliff to west of Nonkraden (4,888) 24½ miles at 250 Rupees.

From point (4,888) to a point about 2½ miles from Lailangkote, 6 miles, at 500 Rupees per mile.

The last 2½ miles at 150 Rupees.

This gives a sum total of 9,500 Rupees for opening up the path to a breadth of six feet.

#### Abstract of Expenses.

Items of Work.	Rate.	Quantity.	Amount
Lacat to the edge of cliff to west of Nonkraden at ...	Rs. 250 per mile	24½	Rs. 6,125
From point (4,888) to a point about 2½ miles from Lailangkote ...	" 500 "	6	3,000
The last 2½ miles at ...	" 150 "	2½	375
Total Rupees ...	.....	.....	9,500

From MAJOR D. BRIGGS, Superintendent of Works in Assam, to LIEUTENANT-COLONEL J. P. BEADIE, R. E., Chief Engineer, Bengal,—(No. 557, dated the 22nd June 1864.)

I HAVE the honor to acknowledge the receipt of your letter (Secretary to Government) No. 2501 of the 16th ultimo, respecting the Gowhatty and Sylhet Road.

3. With reference to the 3rd and 5th paragraphs of your letter, I beg to represent that I have just completed an inspection of the line, carrying my baggage on mules, and that, with the exception of a few places, where projecting stumps of trees had been carelessly left, they had not to be unloaded at any point. Further, on my return to Gowhatty, I breakfasted one morning at 5,500 feet of elevation with a temperature of 54°, and dined the following day at Gowhatty with a temperature of 84°. The mules arrived the day following. Until within the twelve miles of Gowhatty, when the last descent to the Assam Valley commences, the road is never lower than 1,500 feet above level of sea. No member of my Establishment, nor that of Captain Davies, suffered from fever, although the rains had well set in; whereas I returned to Gowhatty to see one favorite old servant, whom I had left at home,

die within two days of my return, and Captain Davies to find nearly all the servants whom he had brought from Calcutta ill.

About the same time persons who had come by the old Nunklow Road, employed in the Survey Department, arrived all, more or less, suffering from fever. These facts prove the general salubrity of the line occupied by the new road, and the easy journey which it will eventually be from Gowhatty to Shillong.

4. The work at present going on is making the road wide enough for the safe passage of beasts of burthen, so as to enable us to move our tools and stores without the help of coolies, so difficult to procure. Also the correction of parts of the line unnecessarily long by reason of entering deep inflections, which the removal of the heavy jungle now permit us to see and to avoid, and which will very materially shorten the distance from Gowhatty to Shillong.

5. Under the above circumstances I beg a reconsideration of that part of your 3rd paragraph where you say: "It were better not to expend any more money in opening out the line." I would desire, for the present, that the sum already sanctioned by the Government of India be at least worked up to.

6. With reference to your 6th paragraph, it is not that there has been discovered any more formidable work than was anticipated between Gowhatty and Shillong that increases the rough Estimate. But it is, that the distance is found to be greater in consequence of the low limit of 4 in 100 fixed as the maximum gradient. Then again, my first Estimate of Rupees 4,500 per mile was held by you to be too low. In my second Estimate, therefore, I assumed Rupees 6,000 per mile, giving masonry culverts where I would otherwise have had dry stone walls. On the basis of my first Estimate the road from Gowhatty to Shillong would only now cost 3½ lakhs, whereas on the basis of my second Estimate it will cost 5 lakhs. I assert that nowhere could an easier line of country for a hill road be found than that I have selected between Gowhatty and Shillong. I am confident that an excellent 24 feet road might be excavated, and dry rubble walls and culverts built at Rupees 4,000 per mile. But the Estimates now under preparation will lay all doubts on this head at rest.

7. The Bungalows for shelter will be put in hand at once and the Estimates submitted for sanction.

8. In regard to the 8th and 9th paragraphs of your letter, I regret that the continuation of the road to the Plains of Sylhet is not to be considered as part of the whole project, as without such communication to the south Shillong will not be well supplied with necessaries, and the state of immobility, which exists at Cherra Poonjee at present for want of carriage, will only be intensified at Shillong. A safe carriage road through Shillong, connecting Assam and Sylhet, would perhaps be of more immediate benefit to Assam than its projected Trunk Road, and could be far more speedily constructed.

9. I think I must have failed in my report to make myself thoroughly understood as to the terminal point of the road in the Sylhet Plain. Although I advocated the extension of the road



to the Station of Sylhet as a convenient case for supplies to Shillong, yet I had in no way shut out easy communication by water to Chhattuck. The enclosed Sketch shows how the Shillong road is lined out to reach the Sylhet Plains; and I beg His Honor's attention to the fact that it strikes the Companygunge River, by means of which there is boat communication to Chhattuck all the year round, and probably depth of water for steamers for six months of the year. This I will have an opportunity of testing during the autumn. The main difference between my first and second projects of descent to the Sylhet Plains is, that in the first I kept to the Valley of the Dooblee. In the second, to avoid the deep inflections and precipitous character of a portion of the first, I kept to the water-shed line. It is the line of the main traffic between the Plains and the interior of the hills, and in January I found that where it reaches the Plains at Lacat, there were hundreds of boats loading for Chhattuck and Sylhet. A road from Lacat to Chhattuck is also quite possible.

10. At present I am opening out a good bridle road from the new Hill Station to the Sylhet Plains, and I am confident that a reference to the Civil Authorities will prove that, putting aside the interests of Shillong, even such a path will be of the greatest service to the opening out of the whole of the Khyrim Rajah's country.

From LIEUTENANT-COLONEL J. P. BEADLE, R. E., Secretary to the Government of Bengal in the Public Works Department, to the Superintendent of Works in Assam,—(No. 3445, dated the 12th July 1864.)

I AM directed to acknowledge the receipt of your two letters No. 312 of the 30th May last and No. 557 and of the 22nd ultimo, to the address of the Chief Engineer, Lower Provinces, on the subject of the proposed lines of road to connect Gowhatty with the Plains of Sylhet.

2. In reply, I am to inform you, as regards the road from Gowhatty to Shillong, that Captain Davies' Estimate for opening out a road 10 feet wide, with timber bridges, at a cost of Rupees 60,464, which was received with your previous letter No. 252 of 20th May last, has been submitted for sanction to the Government of India, on the understanding that nothing further will be attempted than is provided for in the Estimate, pending orders on the detailed Surveys, Sections, and complete Estimates for the formation of a carriage road (20) twenty feet wide.

3. As regards the continuation of the line from Shillong to the south, I am directed to state that the Lieutenant-Governor approves of your proceeding to open out a bridle road from the Hill Station to the Plains of Sylhet; but His Honor requests, at the same time, that the expenditure on it may be confined strictly to the sum of Rupees (5,000) five thousand authorized in the orders No. 5891 of the 9th October last. The approximate Estimate for this bridle road, amounting to Rupees 2,500, is therefore returned.

4. The direction in which the continuation of the road has been lined out as shown by the Sketch now submitted does not accord with the Sketch first received; and in regard to this part of the subject, I am to state that, owing to the present insufficiency of the Budget funds of this Govern-

ment, the Lieutenant-Governor has not the means of carrying out so extensive a work as that of the formation of the proposed carriage road south of Shillong. His Honor is of opinion that it would be advisable to improve, as far as may be practicable, the old line of road south of Moflung, and the pathway already opened out from Moflung to Shillong. On this latter point you are requested to submit a report after consideration.

From COLONEL R. STRACHEY, R. E., Secretary to the Government of India in the Public Works Department, to the Secretary to the Government of Bengal in the Public Works Department,—(No. 4187, dated Simla, the 13th July 1864.)

In reply to your letter No. 2948, dated the 10th June 1864, I am directed to state that the Governor General in Council sanctions, on the conditions named in paragraph 5 of your letter, the Estimate, amounting to Rupees 60,464, for opening out and roughly constructing a 10 feet road from Gowhatty to Shillong.

From LIEUTENANT-COLONEL J. P. BEADLE, R. E., Secretary to the Government of Bengal in the Public Works Department, to the Superintendent of Works in Assam,—(No. 3646, dated the 25th July 1864.)

In continuation of paragraph 2 of my letter No. 3445 of the 12th instant, I am directed to forward to you a copy of a letter from the Government of India in the Public Works Department, No. 4769 of the 13th instant, conveying sanction to the Estimate\* submitted with your letter No. 252, dated the 20th May last, for opening out a road from Gowhatty to Shillong, 10 feet wide, with timber bridges, at a cost of Rupees (60,464) sixty-nine thousand four hundred and sixty-four.

2. This sanction has been accorded on the understanding indicated in my letter of the 12th instant already cited, and I am therefore to point out that nothing further must now be attempted than is provided for in the above Estimate.

3. I am further to request the submission of the complete Estimate, with detailed Surveys and Sections, for the formation of a carriage road, 20 feet wide, which you have stated will be ready by October next; the object being to secure its transmission to the Government of India prior to the preparation of the Budget for 1865-66.

From MAJOR D. BRIGGS, Superintendent of Works in Assam, to the Chief Engineer, Bengal,—(No. 618, dated the 29th June 1864.)

PREVIOUS to the receipt of your letter No. 1011 of the 29th February, I had proceeded to examine a line for the extension of the Assam Trunk Road from Goalpara down the left bank of the Bernam-pooter to Kuri Bari, with a view to the adoption of what I considered the best route between Assam and Calcutta.

2. A former project supposed the line of the Trunk Road to cross the Bernam-pooter at Nalbari and continue onwards to Raingora and Rangpara; to this I was always opposed, on account of the inundated condition of the country and the crossing of the large River, Gouhatee, near

and Teesta, between Doobree and Rungpore. The 5th paragraph of your letter under reply settles the question, and records the Lieutenant-Governor's opinion in favor of the Kuri Bari route.

3. To avoid any misconception as to the route after it has left Assam and entered the Mymensingh District, I will here state that I propose it should, after crossing the old bed of the Berhampooter (now the bed of the Jijeram) at Jumalpoore, pass southwards between the Rivers Attae and Bunsee, and either cross the true Berhampooter to Serajunge by the Soobunkolly Ferry, or proceed onwards till it meets the proposed Railway to Dacca, should that undertaking ever be carried into effect.

4. In my first report on the Assam Trunk Road, I stated that the probable distance from Dibröoghur to Luckeepore, (Metchparah,) south-west of Goalparah, would be 34½ miles. At Luckeepore we take up the line to Kuri Bari, now to be reported on.

5. Luckeepore occupies a slightly elevated ridge in the midst of a plain subject to inundation. As it is the chief village in Metchparah, I think it is of importance that the Trunk

*Section I.*  
Luckeepore to Tikree  
Killah, nine miles; or 35¾  
from Dibröoghur.

Road should pass along this ridge as I have projected. This ridge continues towards the south-west, until, crossing a tributary of the Jijeram, it meets a low range of hills, thrown out from the Garrow Hills, near Garrow Khatta. This low range is cultivated by the Garrows and produces cotton, hill rice, &c. It is of small elevation, of clay formation, and presents no difficulties to the formation of a road. These hills occupy a width of about two miles in the direction of the road, until the cultivated fields of Bamundoobee are met, below which some inundated ground lining the Azaghur Nullah is crossed. Cultivation then extends to a branch of the Gagooah stream, near Tikree Killah, which is one of the outposts guarding the Garrow frontier.

The bridges required throughout this section are—

1 Wrought iron girder, of 60 feet span, for the tributary of the Jijeram,

1 Wrought iron girder, of 40 feet, for the Azaghur,

1 Masonry arch, of 25 feet, for the branch of Gagooah, and 10 culverts of various spans of from 5 to 19 feet.

The earthwork must be taken at a general average of 5 feet in height for seven miles, as the general line of the country is low. Through the spur of the Garrow Hills (two miles) it may be assumed at an average of 8 feet excavation. An abstract of the propositions, and probable cost for each section, will be shewn at end of report.

6. For the first five miles the line lies through a wild country covered with heavy grass jungle with few villages. There are not many places subject to inundation, and the soil being of a rich alluvial character, population is all that is wanted to change the existing sea of grass into a space of cultivation. At present wild elephants

*Section II.*  
Tikree Killah to Bengal  
Khatia, 14 miles; or 40  
miles from Dibröoghur.

and rhinoceros are numerous. Under Tikree Killah the Gagooah is crossed, and several smaller streams, up to near Alugdia. From that to Nowpotah there is more cultivation and the country is higher. Two small streams occur. From Nowpotah to the Rongai River pretty high ground is met with, lying between a mass of swamps lining the foot of the hills and the banks of the Jijeram ramifications. This is partially cultivated, but still there is a great deal of waste grass land. The Rongai River coming fresh from the Garrow Hills has a gravelly bed and a considerable current. It is 100 feet wide. Two miles farther west is Bengal Khatta, another outpost on the Garrow frontier. These two miles are just above the line of inundation.

The bridges required throughout this section are—

1 Of two openings of wrought iron girders, 40 feet each, over the Gagooah.

1 Ditto ditto, of 60 feet each, over the Rongai.

2 Masonry bridges of 20 feet each.

4 Ditto ditto of 16 ditto.

3 Culverts from 5 to 10 feet.

The earthwork may be taken at a general average of 4 feet in height for the whole distance.

7. After rounding the Sharnuggur Hill an inundation nullah, 60 feet wide, is crossed: deep, muddy, and stagnant like the most of the Assam Rivers in the Plain: tidal in its flux

*Section III.*  
Bengal Khatta to Singamaree, 16 miles; or 38¼  
miles from Dibröoghur.

and reflux as the Berhampooter rises and falls. After this crossing, the line of road passes between a range of hills and the Jijeram River on ground well above inundation level, having all the appearance of a bund road, which probably it was, leading to the mass of ruins buried in rank grass and cane where formerly stood the palace and fort of Rajah Bissun Dey. Along this lie the last tea plantations met with in Assam. They belong to the Gowripore Zemindar. After passing the site of the old ruins, an extensive plain, intersected with large lakes, affords pasture to vast herds of buffaloes and cattle. These are sent long distances from Bengal to fatten on the rich pastures of Metchparah and Jumeerah. Passing between the Bhoronee Bheel and the Jijeram, a fair line above inundation level is obtained up to the Kolungkinee River flowing under some low hills, at the extremity of which lies Singamaree. The track usually travelled at present from Bengal Khatta to Singamaree is marked in dotted red through Salmara and Boaleear Haut, but the Map shews what a mass of rivers it crosses. Indeed, during the rains, the whole journey is done by boat. I am well satisfied with the line I obtained, and the opinion of the people of the country was in favor of it. The line crosses only one stream of any magnitude, the Kolungkinee, 180 feet wide, with sandy bottom and moderate current. Immediately after crossing this a low range of hills is reached, through a gorge of which we come down to the south of the great Garrow Haut, or market place of Singamaree. Some low land and affluents of the Jijeram require four bridges of moderate size.

The bridges required throughout the section are—  
1 Wrought iron girder, of 60 feet span, near Bengal Khatta.

- 1 Ditto ditto, of three openings, of 60 feet each, over the Kolungkin.  
1 Ditto ditto of 40 feet.  
1 Masonry arch of 25 feet } Between the Ko-  
1 Ditto ditto of 20 „ } lungkinee and  
1 Ditto ditto of 16 „ } Singamaree.  
12 Culverts from 5 to 10 feet span.

For the earthwork I estimate three miles at an average of 5 feet raising, six miles at 4 feet, and seven at 3 feet, which will also cover the expense of the slight cutting along the base of hills.

8. For nearly nine miles to Jowdangah the

Section IV.  
Singamaree to Kukreeparah,  
15 miles; or 309 from Dibroo-  
ghur.

present path skirts the high bank of the Jijeram through numerous villages and rich cultivation. No difficulties whatever occur, and only a few culverts to carry of the surface water are required. At Jowdangah the present path crosses a channel of the Jijeram and passes on to Mankurchur Haut. This is quite unnecessary; and I found a good line, as shewn on the Map, crossing a small inundation cut, which may be filled in; and crossing the Kaloh River near to some low hills, where it is less than 200 feet wide. The line will generally be above inundation level and run through high cultivation. On skirting the low hills to the east of the Khassbee Bheel three small streams are met with; but the line is high and removed from all fear of inundation.

Rounding the spur north of Kukreeparah Haut we enter a rich cultivated plain well above inundation level.

The bridges required for this section are—

- 1 Wrought iron girder, of three openings, each of 60 feet span, over the Kaloh River.  
2 Masonry bridges of 20 feet span.  
8 Culverts of spans varying from 6 to 10 feet.

The entries in my field book give for earthwork an average of 3 feet raising for the whole distance.

9. For 2½ miles the same favorable cultivated

Section V.  
Kukreeparah to Kuri Bari,  
10 miles; or 415 miles from  
Dibrooghur.

ground above noted extends. Here the Dunee Nullah crosses to west a deep muddy ditch with slack current, where, in consequence of the treacherous nature of the clay bed, a good size single span on low abutments is preferable to intermediate piers. Sixty feet span will be sufficient. At this nullah the present path divides into two; the more direct following the bed of the Jijeram used by the country people as long as it is not in flood, and the other passing through the Garrow hills. I examined both routes and have adopted the safest one with reference to the encroachments of the Jijeram, which is during the rains a channel of the Berhampooter. The mass of low hills into which the Garrow range sinks at its western extremity are generally of clay formation, and, except in causing some sharpish curves, in no way interfere with the construction of a first class road; even these curves need not be of a less radius than 1,000 feet. At only one place will it be requisite to employ a gradient of one in fifty. No streams of any magnitude occur, but a good many culverts will be necessary. The greater portion of the road will lie through scant cultivation, partly in the hands of tributary Garrows and partly in that of various Hindoo castes. At three miles from Kuri Bari the line emerges on the high bank

of the river and passes on over two nullahs to the cultivated plain in which Kuri Bari is situated, the distance from which to Jumalpoore on the old bed of the Berhampooter is about 30 miles.

The bridges required for this section are—

1 Wrought iron girder, of 60 feet span, over the Dunee River.

1 Ditto ditto over the Nokaye.

1 Masonry bridge of 25 feet span.

3 Ditto of 20 ditto.

25 Culverts from 5 to 10 feet in span.

The earthwork required appears to be a general average of 3 feet raising for 14½ miles, and 3 feet excavation for 1½ miles. In addition, 300 running feet have to be cut down an average of 10 feet; 800 running feet to be cut down 7.5 feet, and 220 running feet to be cut down 3.5 feet, all in stiff clay.

For 7½ miles the jungle is dense and ought to be cut down to a width of 200 feet, leaving all the finer trees for shelter.

10. The Abstract attached gives the total cost of the above requirements for all the earthwork and bridges throughout the above five sections as Rupees 3,79,233, or a mileage rate of Rupees 5,379 for 70½ miles. This sum, added to that reported as requisite for the Trunk Road from Dibrooghur to Doobree in my No. 42 of the 7th May 1863, gives a total Rupees 26,09,889, from which has to be deducted the cost of the eleven miles of road from Luckeepore to the banks of the Berhampooter opposite Doobree, or Rupees 69,300, leaving Rupees 25,40,589 as the cost of the Assam Trunk Road from Dibrooghur to Kuri Bari, with bridges over every stream, except the Diheen and Dhunserree Rivers.

11. What I learnt of the country between Kuri Bari and Jumalpoore was that there were no difficulties to the construction of a road and that the present path is travelled all the year round. Also, that the country is well cultivated and that villages abound.

From LIEUTENANT COLONEL J. P. BRADLEY, R. E., Secretary to the Government of Bengal, in the Public Works Department, to the Superintendent of Works in Assam, (No. 3860, dated the 6th August 1864.)

I AM directed to acknowledge the receipt of your letter No. 618, dated the 29th June last, to the address of the Chief Engineer of Bengal, and of its enclosures, containing your Report, after an inspection of the country, on the best route to connect Assam with Calcutta from Luckeepore on the Assam Trunk Road.

2. The Lieutenant-Governor desires me to express his thanks to you for this detailed Report, which has been perused with interest: it will doubtless be found useful hereafter when the upper portions of the Assam Trunk line are completed, and when the Bengal Government may be in a position to carry out the prolongation of the Trunk line to a southern termination in connexion with the system of Railways in Bengal.

No. 3861.

Copy of the above letter, and of the report to which it is a reply, as well as a copy of an Index Map prepared in this Office to illustrate the proposed route, forwarded for the information of the Government of India, in the Public Works Department, with reference to the Resolution received from that Department under cover of Memorandum No. 465 of 30th January last.



From LIEUTENANT-COLONEL R. STRACHEY, R. E., Secretary to the Government of India, in the Public Works Department, to the Secretary to the Government of Bengal, in the Public Works Department,—(No. 4418, dated Simla, the 16th August 1864.)

In reply to your letter, No. 2502, dated the 16th May 1864, I am directed to state that the Governor General in Council agrees generally with the Hon'ble the Lieutenant-Governor in the opinions expressed by him as to the construction of the hill portion of the Assam Roads, and observes, with satisfaction, that Major Briggs has been instructed to lose no time in furnishing Plans and Estimate for the Gowhatty and Shillong Road. If necessary, additional aid should be given to Major Briggs to enable him to complete the project in reasonable time.

2. The orders contained in Public Works Department Resolution No. 465, dated the 30th January 1864, as to the width of the roads, will be adhered to, and the gradients should nowhere be greater than one in twenty-five. The Estimate should be framed for a road twenty feet wide in the hills (including drains and parapet, so as to give *bond fide* sixteen feet roadway, or eighteen feet where there is no parapet) and twenty-four feet in the Plains. As already arranged, however, the hill portion of the road between Shillong and the Plains of Sylhet may be opened out to a width of ten feet only at first.

3. The formation of a separate Executive Division in connection with these roads has been recommended to the Financial Department, and as soon as the necessary sanction has been obtained, Captain Davies may be gazetted to the charge.

4. In conclusion, I am directed to state that the progress which has been made on the Shillong road is considered very satisfactory; and I am to request that the commendations of the Government of India may be conveyed to Major Briggs, both for the work he has done and for the very clear Report submitted by him. All necessary aid in tools and Overseers should be given to Major Briggs, as, without proper provision on both heads, time and money are wasted.

Orders of Government of Bengal,—(No. 4256, dated 29th August 1864.)

Copy forwarded to the Superintendent of Works in Assam for guidance, in continuation of my letter No. 3646, dated the 25th ultimo, and with reference to my previous letter No. 2501 of 16th May last.

From COLONEL R. STRACHEY, R. E., Secretary to the Government of India, in the Public Works Department, to the Secretary to the Government of Bengal, in the Public Works Department,—(No. 4418, dated the 14th September 1864.)

The Report by Major D. Briggs, Superintendent of Works in Assam, of the best route for continuing the Assam Trunk Road, from Luckeepore towards Calcutta, forwarded under cover of your docket No. 3861, dated the 5th August 1864, having been laid before the Governor General in Council, I am directed to remark that the line indicated by Major Briggs may, no doubt, be useful for a road hereafter. But it seems probable that, after the opening of the Upper Assam line, or simultaneously with it, communication with Rungpore and Darjeeling by the route which Major Briggs has rejected will be of more importance than a second line towards Calcutta. Assam will, the Governor

General in Council is of opinion, have a better communication with Calcutta by the Shillong Road, when it is completed, than by any other.

Orders of Government of Bengal,—(No. 5019, dated 21st October 1864.)

COPY forwarded to the Superintendent of Works in Assam, in continuation of letter No. 3860, dated the 5th August last.

2. The Lieutenant-Governor is of opinion, with reference to the last remark of the Government of India, that every endeavor should be made to push on the works on the Shillong Road to the full extent of the grants provided for it in the current year.

Memorandum No. 1678, by LIEUTENANT-COLONEL J. P. BRADLE, R. E., Chief Engineer of Bengal,—(dated the 25th November 1864.)

THE following Report on the upper portion of the Assam Trunk Road, between Debrooghur and Jorhaut, 80 miles, based upon information derived from the Superintendent of Works in Assam, is submitted for the information of Government, and with a view to sanction being accorded to the detailed Estimates, which are accompanied

\* No. 80 of 1864-65. with a general map\* of the  
† „ 663 of „ district and an index map† of the road.

2. As regards EARTHWORK.

An Estimate for the first 4 miles from Debrooghur was sanctioned in 1862; it provided for 26 lakhs of cubic feet at a cost of Rupees 9,001. Of this about 20 lakhs of cubic feet have been completed. From the fourth mile to the Sessa River, a distance of 10½ miles, the old road requires repairs at the rate of 60 cubic feet per foot forward. From the Sessa River to 1 mile east of the Dehing River, 4½ miles, the road requires raising and to be widened at the rate of 120 cubic feet per foot forward.

For 1 mile east and west of the Dehing River nothing can at present be done to the road until the site for the bridge shall have been fixed.

From 1 mile west of the Dehing River to 4 miles east of Seesaugor, a distance of 19 miles, the road requires to be made of uniform section and repaired at about 80 cubic feet per foot forward.

An Estimate was sanctioned in 1862 for the 4 miles of road east and west of Seesaugor, but owing to the scarcity of labor only about 27 lakhs of cubic feet have been completed out of a total of upwards of 70 lakhs.

\* Four miles west of Seesaugor the road joins the "Bor Allee," an ancient embanked road of great section, 30 feet wide on the crest, requiring repairs at the rate of 50 cubic feet per foot forward. The Trunk Road follows this "Allee" from Zalsaghur to the Meetang Seegha, a distance of 3¼ miles, and then to the Jhazee River, 7¼ miles: the line follows another of the old Allees, named the Maskoghur Allee, which also requires mere repair at the rate of 40 cubic feet per foot forward. This road is from 27 to 30 feet wide.

From the Jhazee River to Jorhaut, 20½ miles, there is an existing road about 12 feet in width, and about 2½ feet above the level of the country, which is but very slightly inundated. The road requires to be raised about 1 foot and widened to 24 feet, which will take on an average 75 cubic feet of earthwork per foot forward.

3. There is one portion of the road between Borboorwah and the Deesang River, about 22

miles in length, which passes through a dense forest jungle, which, it is necessary, should be cleared for at least 100 feet on each side of the road to admit light and air and for the safety of travellers. A few of the large trees may be left for shade, but the under-growth should be entirely cleared away.

The total quantity of earth raising required for this 80 miles of road, including the 12 miles which have been separately sanctioned out of the Stations of Sebsaugor and Debrooghur, will be as follows :—

	Length in feet.	Cubic feet per foot forward.	Total cubic feet.
<b>EARTHWORK.</b>			
For 4 miles west of Debrooghur ...	21,120	...	26,00,000
Thence to the Sessa River ...	56,100	60	33,66,000
Thence to the Dehing ...	25,100	120	30,12,000
Thence to east of Sebsaugor ...	81,480	80	67,58,400
For 8 miles through Sebsaugor ...	42,240	...	70,00,000
Repair of Bor Allee..	20,000	50	10,00,000
Repair of Maskoghur Allee ...	37,740	40	15,09,600
From the Jhazee River to Jorhaut..	1,10,000	70	77,00,000
<b>Total</b> ...	<b>3,96,780</b>	<b>...</b>	<b>3,29,46,000</b>
<b>JUNGLE CLEARING.</b>			
Clearing forest jungle	1,16,160	170	1,97,50,000

5. There is therefore about 330 lakhs of cubic feet of earthwork and 200 lakhs of square feet of jungle clearing required for this section of the road, of which about 47 lakhs of cubic feet of earthwork have been completed in two working seasons.

6. As regards BRIDGING.

A Report was submitted to the Government of India in October 1863, shewing what had been done and was still required between Debrooghur and Golaghat, a distance of 107½ miles, which includes the 80 miles now under consideration. It was shewn that on the portion of road between Debrooghur and Sebsaugor, 45 miles, there were—

8 small Bridges completed,  
8 ditto nearly completed,  
2 ditto in progress,  
1 ditto not commenced,

Total 19;

and it was also shewn that 49 small bridges are required on the road between Sebsaugor and Golaghat, which were subsequently sanctioned by the Government of India at an outlay of Rupees 59,082.

7. Of the above 49 bridges progress on those between Jorhaut and Sebsaugor is reported as follows :—

In approach to Deekoo... 10 feet span, completed.  
Joomtollee Nullah ... 22 feet span, within 4 feet of spring.  
Kagootee Nullah ... 22 feet span, within 3 feet of spring.  
Halwa Shigha ... 24 feet span, up to spring.  
Jameegooree ... Not commenced.  
Koliapance ... Ditto.  
Laloonjan ... Up to spring.  
Nyebassa ... Ditto.  
Kurtbee Jan ... Ditto.  
Badlee ... 10 feet span, up to spring.  
Leepurjai ... 10 feet span, up to spring.  
Karkeekowar ... 10 feet span, up to spring.  
Goseah ... 8 feet, not commenced.

8. In addition to the foregoing it appears that the Meenang Nullah has been bridged with one span of 24 feet, and is completed as regards masonry, though the approaches are still wanting. This is one of the nullahs mentioned in the

Report of October 1863 as being classed with the larger streams as noted in the margin, for which no provision has as yet been made for bridges.

9. Estimates are now submitted for bridging the following nine streams :—

1. The Phoolpance ... 3 spans of 15 feet, to cost ... Rupees 5,325	13. Boodaijan.
2. " Jhogdee ... 2 " " " " " 4,186	14. Khakoo.
3. " Teok ... 2 " " " " " 4,156	15. Jheadeah.
4. " Bhodun Jan... 3 " " " " " 8,858	16. Moree.
5. " Khaka Jan ... 3 " " " " " 8,358	17. Meenang.
6. " Jheadeah ... 3 " " " " " 5,325	18. Bhogdoi.
7. " Mooredeah ... 2 " " " " " 4,156	19. Dheeke.
8. " Meenang ... 2 " " " " " 4,156	20. Dhollee.
9. " Bhogdoi ... 2 " " " " " 4,156	21. Kucha.
	22. Dhoorsrai.
	23. Kaka.

The bridges to be of masonry superstructure, supporting iron beams topped with a platform of timber; the roadway to be 16 feet wide.

10. This still leaves five rivers between Debrooghur and Sebsaugor, (Nos. 1 to 5,) and three rivers between Sebsaugor and Jorhaut, (Nos. 6, 8 and 10,) also five rivers on the road between Jorhaut and Golaghat, for which no provision has yet been made.

11. The amount of the Estimates to which sanction is now solicited is—

Earthwork ... Rupees 2,02,352  
Bridges ... " 48,146

This will absorb the sanction given in 1862 to an Estimate amounting to Rupees 9,001 for the earthwork for 4 miles west of Debrooghur, and will make the total amount of Estimates sanctioned for the Assam Trunk Road in the Upper Assam Division—

Earthwork ... Rupees 2,02,352  
Bridge-work ... " 1,48,146

12. Whilst submitting these Estimates, which may be trusted as shewing the quantity of work required, the Chief Engineer feels it necessary to warn Government that, under present circumstances, very little reliance can be placed upon any Estimate of the outlay to be incurred on works in Assam, which must necessarily, under existing

circumstances, be spread over several years. In the absence of local labor it will be necessary, if works are to be proceeded with in a manner commensurate with the requirements and claims of the Province, to make arrangements for a supply of laborers and artizans from other parts of Bengal. About 300 coolies and a score of artizans were sent up to Assam in 1862-63, and although the result has not been so satisfactory as could have been wished, it affords promise that the scheme would answer if properly undertaken.

13. The difficulties to be overcome are of two kinds. The difficulty in accounting for the expenditure in accordance with the sanctioned outlay; and the difficulties in obtaining the number of laborers required and in maintaining them in the Province of Assam.

In regard to the first, it may be explained that the Estimate for works in the usual form provides for a certain number of units of work being completed at certain rates and within a certain total amount: but the expenditure would actually take a totally different form not comparable in any way, for some years, with the sanctioned Estimate. For instance, a considerable amount would be expended in collecting laborers, probably in Behar and Chota Nagpore, in bringing them down to Calcutta and in sending them to Assam, which amount would be recovered gradually during the three or four years the laborers would be employed in Assam. In fact, the actual payments to laborers whilst employed in Assam would not be more than two-thirds of the total outlay on their account.

14. The proper form, therefore, in which sanction should be accorded to any such work as the Assam Trunk Road would be to the raising and maintenance of a body of work-people from year to year; of course, the ultimate rate and cost of work could be ascertained, but in the meantime the monthly expenditure would be comparable with the Estimate, which it is not in the case of imported labor into Assam under the present system of Estimate based on rates and the cost of a work.

15. Heretofore we have debited all expenses incurred in sending coolies and artificers to Assam to a suspense account, which has been credited with the value of their labor at a fixed rate sufficient to cover the payments for wages and the preliminary expenses incurred. On a limited scale there is no objection to this practice, as the Budget grant for works has been sufficient to cover the debits to the suspense account; but on a large scale there would be this objection, that there would be no particular grant in the Budget against which the preliminary expenses could be charged. For instance, to carry on works in a manner to make a visible impression, at least 2,000 laborers and artizans should be sent up to Assam without delay; this would entail a preliminary outlay of about 70 Rupees per head, or 1,40,000 Rupees, which would be gradually worked off, or covered during the following three years.

16. The practical difficulties arise owing to the want of means for enforcing any specific contract for labor which might be entered into. This is a subject for the Government to consider in the Legislative Department, and which, it is probable, will shortly be overcome. It is therefore necessary for the Chief Engineer to enter more fully into the question.

From LIEUTENANT-COLONEL J. P. BRADLE, R. E., Secretary to the Government of Bengal in the Public Works Department, to the Secretary to the Government of India in the Public Works Department,—(No. 223, dated the 14th January 1865.)

With reference to the previous correspondence noted on the margin, I am directed by the Lieutenant-Governor to submit, for the consideration of the Government of India, a Memorandum, No. 1678, dated the 25th November 1864, from the Chief Engineer, with the Drawings and Estimates which accompanied it for the earthwork and for certain bridges on that portion of the Assam Trunk Road which is in the Upper Assam Division.

2. Of these two Estimates, No. 321 of 1864-65 provides for placing the whole line of road between Debrooghur and Jorhaut, 80 miles, in a thoroughly efficient state, as regards the earthwork formation only, at a cost of Rupees 2,02,352. The Estimate No. 322 of 1864-65 provides for the construction of nine bridges, affording 372 running feet of waterway, on the same portion of road, at a cost of Rupees 48,146, or nearly Rupees 130 per foot forward.

3. Estimates have already been sanctioned for all the smaller bridges on this portion of the Trunk Road, but there will still remain thirteen\* large streams unprovided for when the nine bridges included in the present Estimate shall be built.

4. Including the Estimates now submitted, the aggregate amount of the sanctioned Estimates for work on the Trunk Road in the Upper Assam Division will be—

For earthwork	...	Rs. 2,02,352
„ bridges	...	„ 1,48,146

Total Rupees 3,50,498,

and Estimates have still to be submitted for the earthwork on the portion of road west of Jorhaut, and for bridges over the thirteen streams above-named.

5. In soliciting sanction to the Estimates now submitted, the Lieutenant-Governor is desirous of drawing special attention to the 12th and following paragraphs of the Chief Engineer's Memorandum, and to the necessity which exists for adopting such special measures as will effectually tend to remove the difficulty experienced in obtaining laborers and in maintaining them in Assam.

6. Considering these difficulties, and concurring in the opinions expressed by the Chief Engineer, the Lieutenant-Governor is desirous of making provision in the Budget of 1865-66 for sending up 800 laborers for carrying on work on the Assam Trunk Road; but as this measure is one which would bind the Government to a certain fixed outlay for the next three years, it appears necessary to obtain the special sanction of the Government of India to the measure.

7. Adopting the data afforded in the Report on the Estimate for earthwork, it would appear that the outlay necessary for sending up one



hundred men and maintaining them in the Province would be (omitting fractions)—

1st year	...	...	Rs. 12,000
2nd "	...	...	" 6,000
3rd "	...	...	" 4,500
4th "	(4 months)	...	" 1,500

Total, Rupees 24,000

And the outturn of earthwork would probably be—

1st year (8 months)	...	12,00,000 cubic feet.
2nd "	...	" 16,50,000 "
3rd "	...	" 14,50,000 "
4th "	(4 months)	" 5,00,000 "

Total ... 48,00,000 cubic feet.

8. The number of men which it is proposed to send up in 1865-66, viz. 800, with the small amount of local labor available, would probably complete the whole of the work provided in the Estimate for earthwork now submitted, by the rains of 1868, and the annual Budget grants required would be, including a provision for local labor,—

1865-66	...	Rs. 1,00,000
1866-67	...	" 50,000
1867-68	...	" 38,000
1868-69	...	" 14,352

Total amount of the Estimate, Rs. 2,02,352

As this course of sending up labor must be adopted in the case of all works in the Province of Assam, which are to be proceeded with in a measure commensurate with the requirements and claims of the Province, it is necessary to obtain the approval of the Government of India to the scheme, as the liability incurred will extend over at least three years, and the expenditure of funds is not, as pointed out by the Chief Engineer, directly comparable by the Central Office with the Estimate for work.

From COLONEL R. STRACHEY, R. E., Secretary to the Government of India in the Public Works Department, to the Secretary to the Government of Bengal in the Public Works Department,—(No. 141 C, dated the 13th February 1865.)

In reply to your letter No. 223, dated the 14th January 1865, I am directed to communicate the sanction of the Governor General in Council to the Estimate therewith submitted, amounting to Rs. 2,02,352, for the earthwork of 80 miles of the Upper Assam Division of the Assam Trunk Road.

2. In regard to the nine bridges, for which an Estimate, amounting to Rs. 48,146, is also submitted with your letter, I am to state that, looking to the heavy outlay that will be required on the Assam Roads, His Excellency in Council is of opinion that for such moderate spans as are proposed, it will be preferable to construct these, and generally all bridges of small span, with timber girders, which, according to the rates entered in the Estimate, may be expected to come to only one-fourth or one-fifth the cost of iron. In the present Estimate it is considered that at least Rs. 10,000 may be struck out under this head, and the Estimates for the bridges are accordingly sanctioned for only Rs. 38,146

3. With reference to paragraphs 5 to 8 of your letter regarding the formation of a Labor Corps for the works on this Road, I am directed to state that the Governor General in Council is of opinion that such a measure should be looked upon as a last resource. Whenever recourse has been had to such a mode of procuring labor, the result, so far as the experience of the Government of India exhibits, has not come up to the expectation. Should the Hon'ble the Lieutenant-Governor consider that in the present instance it is expedient, any outlay incurred must be charged to the road work and be met from the General Budget grant.

### Services under local Acts not permitted to count for Pension.

From the RIGHT HON'BLE SIR CHARLES WOOD, Bart., M. P. and G. C. B., Her Majesty's Secretary of State for India in Council, to His Excellency, the Right Hon'ble the Governor General of India in Council,—(No. 302, dated London, the 16th December 1864.)

PARA. 1.—I have considered in Council your financial letter dated the 13th September last, No. 127, relative to a proposition made by the Government of Bombay to permit service on the Establishments employed under Act No. XIX of 1863 of the Bombay Legislative Council (Cotton Frauds Act) to count for pension under the Uncovenanted Service Pension Rules.

2. To this proposition you object on the ground that the Cotton Frauds Act is not a general but a local Act based on local Fund the income of which is connected with the operation of the Act. You state that the Government of Bombay has, without consulting our Government, appointed an Establishment under the Cotton Frauds Act, consisting of a Chief Inspector, at Rupees 1,800 a month, a Sub-Inspector at Bombay, whose salary is not stated, and six European Inspectors, at Rupees 700 each; and you observe that, if the Local Governments are allowed to exercise the power of binding the Government of India to expenditure out of the general revenue under these local Acts, the full control over that revenue hitherto possessed by the Government of India must obviously cease.

3. It appears to Her Majesty's Government that the proposition made by the Government of Bombay ought not to be sanctioned. If it were admitted that servants appointed under local Acts, whose salaries are paid from fees levied under the provisions of those Acts, were to be granted superannuation pensions out of the general revenue, the charge to the State for those pensions would be largely and indefinitely increased. The correct principle in regard to superannuation appears to be that pensions should be granted out of the same funds from which the salaries have been paid.

4. In order to bring the Cotton Frauds Act, which was exceptional in its character, into speedy

and effective operation it was deemed expedient by the Government of Bombay to sanction the employment under that Act of some of their servants, their salaries while so employed being paid from the local Fund. Under the peculiar circumstances of the case Her Majesty's Government will not require that the time so occupied shall be excluded from the period calculating as service for pensions from the public revenues.

5. I have, however, requested the Bombay Government to take the earliest opportunity of restoring the Officers referred to to their proper position in the regular service, and I should hope that any necessity for a similar employment of Government servants will be very rare. It must be garded as a fixed rule that Officers of Establishments employed under local Acts will not be entitled to any pension or allowance from the State.



## SUPPLEMENT TO The Calcutta Gazette.

WEDNESDAY, MARCH 8, 1865.

### OFFICIAL PAPERS.

A SUPPLEMENT to the GAZETTE will henceforward be published, containing such Official Papers and Information as the Government of Bengal may deem to be of interest to the Public, and such as may usefully be made known.

Non-Subscribers to the GAZETTE may receive the SUPPLEMENT separately on a payment of six Rupees per annum if delivered in Calcutta, or twelve Rupees if sent by Post.

No Official Orders or Notifications, the publication of which in the GAZETTE is required by Law, or which it has been customary to publish in the GAZETTE, will be included in the SUPPLEMENT. For such Orders and Notifications the body of the GAZETTE must be looked to as heretofore.

#### Papers relating to a Project for the Drainage of the Calcutta Maidan.

Report by CAPTAIN S. T. TREVOR, R. E., Garrison Engineer of Fort William, — (dated the 26th November 1864.)

INSTRUCTIONS were issued to the Garrison Engineer by the Secretary to the Government of Bengal in letter No. 1586, dated 31st March 1864, to undertake the improvement of the Drainage of the Maidan, and a Report and Survey prepared by Mr. Rayner, C. E., during November and December 1863 were forwarded for his guidance. The points to be primarily attended to were to clear out certain drains which were reported to be choked up, and to lower the sills and enlarge the waterways of all drain bridges which obstructed the free discharge of the water. An Assistant Engineer of experience, aided by a competent Establishment, was promised to look after the work; and it was further directed that, during the progress of the work, attention should be paid to the entire system of Drainage for the Maidan, with a view to the collection of all necessary data, and the submission of a complete and fully matured project for the consideration and orders of Government.

2. It appears not to have been found practicable to post any Assistant Engineer for this special duty as at first contemplated, and I have had therefore to prepare the project, as best as I could, with the Establishment already at my disposal. This has caused some delay, which I trust will be excused under the circumstances.

3. The first step in the preparation of this project was, of course, to consider thoroughly all Mr. Rayner's proposals for the improvement of the Drainage. The conclusion I arrived at after testing most of the measures he proposed, to the extent of actually carrying them out, was, that a far more radical change was required than anything he contemplated. In the 87th paragraph of his Report he says: "All that appears necessary to

improve the Drainage is to clear out all the gutters and drains to level of platforms: to deepen and rectify those gutters which slope away from their points of discharge; to construct a new drain at the south end of the Maidan near the Cooly Bazar; to sink the platform of the five arched drain in the Ellenborough Course; to clean and repair the sluice drain and all the drains; and, if approved, to thorough drain certain portions of the Maidan." Now, in fact, so much of these proposals relates to the mere clearing out, repairing, and adjusting existing drains was annually attended to by the Conservancy Establishment under the orders of the Commissioner of Police and his subordinates. And, moreover, the conservancy was managed, on an average, as efficiently as any other system is likely to be. The failure of the drains, therefore, to carry off the water was due more to their own inherent defects than to want of proper conservancy. At the time of Mr. Rayner's inspection they were found to be choked up in many places, but this was after the close of the rains when there was no scour through them, and when the Establishment had ceased to clear them out. Under these conditions, and indeed under much more favorable ones, I should not expect the old drains to be otherwise than choked up, having experienced, as I have, how rapidly they are destroyed by cattle, &c., passing over them. Some of the drains expressly mentioned by Mr. Rayner as being very bad, as, for instance, that between Dhurrumtollah Tank and Chowringhee Road — (paragraphs 3, 4 and 12) — used to be cleared out six or seven times each rainy season so rapidly did they get fouled from the traffic on them. In short, wherever the water was found to be obstructed in any of the drains, and the obstruction was one that could be removed, it was the habit of the Overseer of the Maidan Establishment to put his men to work at once to clear it away. Some drains, like the outlet to the east of the General Hospital, were beyond his power to keep clean:



but I am convinced that on the whole the most was made of the existing drains that could be with ordinary care, and that the general tendency of the drainage has for years past been towards improvement, and not towards deterioration, as one might suppose from Mr. Rayner's remarks.

4. Exclusive, then, of mere clearing operations Mr. Rayner's proposals for the improvement of the Drainage are the following:—

(1.) To construct a new drain at the south end of the Maidan near Cooly Bazar. This will be found included in my project.

(2.) To sink the platform of the five arched drain in the Ellenborough Course. My level shew this to be already too low with reference to the bridges next above and below it. I have not therefore proposed to lower it, but kept it at its present level and adjusted the other bridges, as will be seen further on.

(3.) To "thorough drain" (*i. e.* with underground drains) certain portions of the Maidan, which I cannot concur in the necessity of.

5. Under these circumstances, then, according to my views, Mr. Rayner's proposals were inadequate to the thorough and radical improvement of the Drainage which I conceived to be required. I have only spoken of them above in a general way, but I have examined and tested each of them separately for my own satisfaction, and am convinced that nothing short of the complete scheme which I now propose will suffice to place the Drainage on a sound footing.

6. On the accompanying plan I have shewn the area of the Maidan divided into several portions, each draining to one outlet. The object of this division is to shew the rainfall which each outlet has to discharge, and to enable a calculation to be made of the capacity proper for it. It will be seen that there are three main outlets for the portions severally tinted green, yellow, and blue on the plan, which comprise nearly the whole of the Maidan, and with which this report will specially have to deal, as the remaining outlets are all minor ones which require little or no alteration. Of these minor outlets there are four on the southern circumference of the Maidan, excluding Cooly Bazar, which will be specially treated of in a separate project, two at Fort Point, and one near the Dhurumtollah Tank, which discharges into the old sewer passing under Government House to Chandpal Ghât.

7. The greater part of the Maidan is very flat, so that no amount of mere trench cutting will prevent it becoming spongy during the rains, unless the surfaces between drains are sloped in some degree towards the drains to allow the water to flow off quickly and completely. To make the drainage a good job, therefore, it must be considered in two aspects; first, the excavation of trunk and branch drains of sufficient capacity to carry off the rainfall; and second, the adjustment of the surface of the ground where it has no natural slope, so that it may throw off the water quickly into the drains. I shall consider these separately.

8. First, as regards the drains. The direction of these is fixed by the natural levels of the Maidan. By placing the accompanying tracing of Mr. Rayner's map of the old drains, which has been of great use to me, over the new map, it will be seen that the general direction of the drains is not much altered, but that they have been straightened and carried more directly to their outlets than before. It will also be seen that the new drains

are proposed to be carried *past* the tanks and not *through* them as before. This is with the object of preventing the tanks being mere silt traps to the drains, as they now are, and of having the power to fill the tanks at pleasure after the first burst of the rains has cleaned the Maidan of all refuse matter. A new arrangement has been made by the present Commissioner of Police, in consultation with the Garrison Engineer, to stop the grazing of cattle in those portions of the Maidan which form the gathering grounds of the tanks during the four months June, July, August, and September, in order that the water flowing into the tanks may not be fouled; and also to prevent the drains from getting trodden out and destroyed at this particular season. This, added to the altered arrangement of the drains, which will place the tanks completely under control as to the admission of water, and enable the water even to be filtered before admission, if necessary, will be an important feature in the improvements proposed.

9. The capacity or sectional area of the drains and waterways of the bridges is a matter that requires more attention than any other in the Maidan. The old bridges are, almost without exception, all too small, and this has been the cause of the Maidan flooding to the extent it does after every tolerably heavy shower of rain. For example, the culvert under the Strand Road, situated between the south end of the Eden Gardens at the Fort has a span of 4 feet with a semi-circular arch, the height of the piers being 3 feet 3 inches. The fall of the drain is 3 feet per mile. When, therefore, the water rises to the spring of the arch, there is back-water along the whole length of the drain right up to the interior of the Maidan, and the Drainage is interrupted proportionately as the discharge through the culvert is insufficient. I have seen the water frequently during the last rains rise not only to the spring of the arch, but a foot or two over the top, totally submerging the whole orifice of the culvert and turning the Maidan into a sheet of water. This happens usually during the freshes, when the water in the river is as high as the culvert, and the latter is placed in the condition of a bridge, with water on both sides nearly on a level, and the velocity of the stream through it about 250 feet per minute, which is the proper condition to attach to it in calculating its size. When the river is low, the culvert is in the condition of a sluice discharging water dammed up on one side of it with a velocity of about 500 feet per minute. But in both conditions the area of the culvert below the spring is too small, for the larger discharge, with the river low, would be 6,000 feet per minute, and the smaller, with the river high, only 3,000 feet per minute. Whereas, according to my calculation, assuming the rainfall at half an inch an hour, for the reasons given in the next paragraph, the culvert should be capable of discharging 10,788 cubic feet per minute.—(See Table on the plan.)

10. The rainfall I propose to assume in calculating the capacity of the Maidan drains is 12 inches in the 24 hours. The actual rainfall has been known to reach 11.73 inches in the 24 hours; but it is not on this ground so much as a consideration of the rate at which the rain really does fall while it is raining that I propose to assume the proper rate of discharge at half an inch per

hour. The heaviest rain, when perhaps 2 or 3 inches fall, is extended generally only over a couple of hours or so, and I think, as it is the whole object of the project to keep the Maidan from getting soft and spongy, water should not be allowed to lie on it an hour longer than can be avoided. The rate of discharge should therefore be made as nearly equal to the actual rate of fall as possible. And this will appear the more necessary when it is considered how often heavy falls of rain and high tides occur together, when the latter prevent a free discharge from the drains and keep the ground unavoidably under water for many hours together. I am aware that in the Calcutta Drainage scheme the capacity of the sewers is only calculated to provide for a fall of 6 inches in the 24 hours, and with the precautions taken in providing vents for storm-waters, no serious inconvenience is apprehended when the rainfall exceeds this limit. But the consideration of expense is one which naturally weighs infinitely more in this case than in that of digging mere open trenches on the Maidan, and building the few culverts that are required, with a sufficiently liberal waterway to meet all contingencies. It is not as if the existing culverts were suited to the 6-inch rainfall and were only proposed to be altered because I considered that rainfall insufficient; but they have to be altered under any circumstances, and the additional expense of adapting them at once to the 12-inch rainfall is so trifling, that there can be no question as to the propriety of doing so. I have seen the drains near their outlets get swollen to the size of streams over a 100 feet in breadth after heavy showers, and I am certain that if it is desired to confine the water to the channels cut for it, instead of spreading over the Maidan, it is essential that the bridges should have their waterways enlarged at least to the extent provided for them in this project.

11. The section I propose for the drains is shewn on the plan, on which there will also be seen a Table giving the arrears of a drain of the assumed section for every additional inch of depth, and also the velocities and discharge through the same, as well as the waterways of the bridges. There is a note at the side of the Table explaining its use. In the assumed section of the drain the side slopes are 5 to 1, and bottom equal to five times the depth. This is sufficiently shallow and saucer-shaped for the Maidan, in which deep drains are inadmissible. The hydraulic mean depth of a drain of this section running full is equal to the sectional area divided by the

perimeter  $= \frac{10d^2}{15.198d} = .658d$ . I have made the fall of the bed of the main trunk drains 3 feet per mile, and with these data calculated the velocity in terms of the depth from the Formula  $V = 55\sqrt{2f} \times H$  where  $f$  is the fall and  $H$  the hydraulic mean depth.—(See Beardmore's Hydrology, page 8, Table 4.) In order to determine the contraction which might be given to the waterway through the bridges, I have assumed the velocity to be increased in the proportion 3 in the drains to 5 under the bridges. This is purely an assumption, and I have no better reason for it than that it is necessary to make some assumption, and this suits very well within the limit I have given to the depth of the drains. For greater depths the acceleration would of course become excessive. The accelerated velocity being

thus fixed, the contracted waterway of the bridges is obtained from the Formula

$$s = \frac{S \times V \times 1.097}{v}$$

where  $S$  and  $V$  are the area and velocity of the natural waterway, and  $s$  and  $v$  those of the contracted waterway. Substituting for  $S$  its value in terms of  $d$ , viz.  $10d^2$  and for  $v$  its assumed value  $\frac{3}{5}V$  the formula gets reduced to  $s = 10d^2 \times \frac{3}{5} \times 1.097 = 6.58d^2$ ; and if the height of the abutments of springing line be assumed as equal to  $d$ , the depth of the drain, then the span of the arch, or aggregate span of the arches if there is more than one, will equal  $6.58d$ , which happens to be just ten times the hydraulic mean depth.

12. The Table thus becomes very useful in enabling the size of drain or culvert required at any point of the Maidan to be at once determined. The plan is ruled into squares of 100 feet side, or 10,000 square feet area each. The rainfall being taken at half an inch per hour, the discharge per minute per square is equal to  $\frac{10,000}{24 \times 60}$  cubic feet = 6.9444 cubic feet. Hence the discharge from any given area on the plan is equal to the number of squares in it multiplied by 6.94. The discharge being thus determined, the size of drain or culvert is at once found from the Table. The section and level of the drains being fixed, it will, of course, sometimes happen that the variations in the level of the ground will afford either more depth to the drain than is required, or not enough. As both these conditions are objectionable, the former on account of the unnecessary inequality it gives to the surface of the Maidan, and the latter on account of the flooding it would allow over the banks of the drain, I propose to remove the earth from where it is shewn to be too high to the low parts, so as in all cases to assimilate the section of the drain to the standard.

13. I will now pass on to describe each of the main drains in succession. No. 1 is the outlet of that portion of the Maidan tinted green on the plan. The sections along this line of drainage will be found in one of the sheets. It is the largest of the drains and contains the greatest number of bridges, the whole of which require to be re-constructed. The available fall in the trunk line is 3 feet per mile after shortening the direction to the utmost, and there is one point in connection with this shortening which requires notice. The old drain from the river eastwards as far as the Ellenborough Course followed the trace of the glacis of the Fort for the sake of being enfiladed, and the effect of this was to give it a very tortuous course. In order to make the most of the fall, I propose to straighten the drain as shewn on the plan, and by continuing the slope of the glacis into the drain avoid any objections that might be taken to the alteration of the trace on the score of defilade. The section of the drain will be thus assimilated somewhat to that of an advanced ditch. It is of course important not to lose sight of this military view of the matter; but it is also important to be careful as to the efficiency of the drainage, and I think the construction I have proposed for the drain will suit both conditions very well.

14. In fixing the general level of this line I have taken the five arched culvert under the Ellenborough Course as the starting point and laid

down a slope of 3 feet per mile above and below. The feeders discharging into the trunk drain have generally a greater fall than this, as will be seen in the sheet of sections. The five arched culvert under the Ellenborough Course is the most obstructive of all on this line on account of the low level of the floor. It gets drowned by every heavy shower, and it can then only act as syphon. I propose in this project to re-build it with only three arches, each of 5' 4" span and 23" height of piers, the old floor and abutments being retained. The waterway below springing will be increased by this means from 10 square feet to 30. The Table on the plan shows 36.74 as the sectional area of the drain required at this point, and 12.62 as the aggregate span of the arches. The proposed alteration of this bridge will therefore render it more than sufficiently large.

15. The bridges on the Calcutta and Plassey Gate Sorties, respectively, at present consist of three spans, each of 2' 3" with height of 2' 6" in the piers, the floor of the centre arch in each case being sunk 6 inches lower than the side arches. I propose to convert them into single spans of 16 and 13½ feet respectively. The positions of these bridges will be altered to the north of the existing ones to suit the new position of the drain, which will also require the arches to be built skew.

16. The bridge under the Strand Road I have already alluded to in paragraph 9: I consider that the full span shewn in the Table to be required for this bridge, viz. 16½ feet, should be given to it. It will be seen from the section that during the rainy season (which is the time when the bridge is used as a drain) the mean height of the river is about on a level with the floor of the bridge. The flow of water through the bridge will be variable according to the state of the tide. It will be altogether stopped at high water, be even and uniform with the flow in the rest of the drain at half tide, and be immensely accelerated at low water. The mean of these conditions, viz. that at about half tide when the flow is even, like it would be through any other bridge, is the one I propose to adopt, and the span given by the Table is applicable to it.

17. It will be necessary to furnish this bridge with flood-gates to prevent the influx of the tide, and it will be the duty of the Conservancy Establishment of the Maidan to attend to them. The present bridge is furnished with a common valve sluice which never acts properly. The design of the new gates will be given separately with the plans and estimates of the several bridges, and I need not therefore describe it here. There is nothing further on this line which requires special mention, or which will not be easily understood at once from the plan, so I will pass on to Line No. 2.

18. This drains the portion of the Maidan tinted yellow, and discharges into the Peepulputtee drain, and thence into Tolly's Nullah just above the site of the old foot-bridge. The discharge from the Maidan by the outlet at the bridge on the Lower Circular Road near the south-east corner of the Jail amounts to 7,307 cubic feet per minute, which requires a bridge with 14 feet waterway. The present bridge has only 6 feet, which, according to the Table on the plan, is only capable of taking off a discharge of 878 cubic feet per minute, or not so much as one-eighth of the quantity it should take off, i. e. it is only suited to a rainfall of about 1½ inches in the

24 hours. There are three other bridges, which require re-construction on this line in accordance with the tabular dimensions. It is, perhaps, necessary to remark that the line of water-shed between the green and yellow portions will not practically be so straight and decided as that drawn on the plan, and that the ground is by no means highest along that line, but, on the contrary, very flat and swampy.

This fact induced me to bring as many discharging outlets to bear upon it as possible in order to carry off the rainfall quickly. The surface of the ground here is the flattest of any portion of the Maidan, and to drain it properly it will be necessary to cart a good deal of earth and get some slope towards the different drains.

19. This drain when it passes the Lower Circular Road goes out of the jurisdiction of the Commissioner of Police and the Garrison Engineer. Under instructions from the Superintending Engineer, however, I have included the whole line as far as Tolly's Nullah in my section, though I do not think it possible, or indeed desirable, that I should have charge of the work of improving it beyond its junction with the Peepulputtee drain. This drain takes the discharge from the whole of the southern end of the Town, and is a very large affair compared with that which brings down the Maidan drainage into it. This latter up to its confluence with the Peepulputtee drain might, perhaps, be placed under the Garrison Engineer, as it may have some effect on the sanitary condition of the General Hospital, which is also under him; but beyond that point the interests of the Municipal Commissioners for the Town and Suburbs predominate, and they should have the charge of carrying out any improvement of the drain that may be necessary. Under this impression, therefore, I shall confine my remarks to the drain from the Lower Circular Road past the east wall of the General Hospital compound.

20. The section assumed for the drains on the Maidan will be no longer applicable here, for there is not the same necessity for its being shallow and saucer-shaped. The side slopes of the drain may now be made 2 to 1, and as the discharge is 7,307 cubic feet per minute, and depth say 2½ feet, the bottom width of the drain may be calculated from Table 4 of Beardmore's Hydrology, page 40, to be 12 feet. This will make the total width of the ground taken up by the drain 32 feet. Allowing 10 feet on each side of the drain, I recommend a space of 52 feet being taken up along the east wall of the Hospital compound and fenced in to prevent encroachment by the Natives living in the neighbouring houses, who are now in the habit of using the drain as a privy. The winding portion of the drain after it leaves the south wall of the Hospital up to its junction with the Peepulputtee drain is now, for the most part, confined between brick buildings, so as to be almost a pukka drain. I recommend that all the intervening spaces from house to house, where the drain is not already revetted, should be so, as well as the floor lined with brick-on-edge, in order that a permanent section may be given to the drain, and every facility offered for keeping it in proper order for the future.

21. As a permanent and final project, the best plan would be to prolong the drain straight past the east wall of the Hospital to its junction with the Peepulputtee drain, and take up enough ground to form a lane or small street alongside of it.



opening from the Lower Circular Road into the Peepulputtee Road. This would have the advantage of ventilating the neighbourhood and making the drain public and under supervision of the Police so as to prevent nuisances from being committed in it, which it seems almost impossible to do so long as it passes through private ground as it does now. In paragraph 30 of his Report Mr. Rayner states that the sewer from Zeerut or Alipore Bridge will intercept this drain across the road and be compelled to receive the drainage of this part of the Maidan. But as the sewer is to be only 12.5 feet above datum at its inlet in Tolly's Nullah, and is to have a fall of 2 feet in the first half mile, while the drain bridge is 17 feet clear above datum, the drain may be made to pass over the sewer, unless it appears that there is any advantage to be gained by joining them. The Town Drainage scheme does not provide for the surface drainage of the Maidan or any portion of the Town outside the Circular Road, and I do not anticipate, therefore, that it will be possible to join them or to dispense with the Peepulputtee drain; and it is worth while therefore to put the latter on a permanent footing at once. In this case it will be best to open out the lane and make the Maidan drain a straight line from the Lower Circular Road as far as the Peepulputtee Road, as recommended above.

22. Whether this be done or not, however, it is of immediate importance to fence in the drain along the Hospital wall and clear away all huts within 50 feet of the wall, and also to complete the gaps in the bricked sides of the winding portion of the drain south of the Hospital. After giving the proper section to the drain mentioned in paragraph 20, I propose to turf the sides and metal the bottom with broken brick, which is available on the spot from a building about to be dismantled in the north-east corner of the Hospital.

The cost of this work will be found included in the general estimate given in the last paragraph of this Report.

23. Line No. 3 takes the drainage of the portion tinted blue on the plan. The general fall of the trunk drain of this line, like the others, is 3 feet per mile. A great portion of the area drained by it will form the gathering ground of the tanks about to be dug for the Fort water-supply, and the arrangement of the drains has therefore been made with reference to this. The position of the tank is shewn in the plan. It will be seen that I propose to make a catch drain all round the foot of the glacis to collect the water thence and bring it to a point between the tanks conveniently situated for admitting the water into them till they are full and after that into the trunk drain. My calculations shew that the drainage from about 82 acres is required for the Fort water-supply, but I confess my conviction is that the drainage from the glacis alone will be found amply sufficient. As it will not do, however, to rely on convictions only, I have arranged the Drainage by bringing the trunk drain close past the tank, so that the discharge from a much larger area can be thrown into the tank if necessary. In fact, on an emergency, when one would disregard the inconvenience of the ground getting somewhat flooded, almost the whole of the Drainage from the area tinted blue might be turned into the tanks by closing the outlet towards Prinsep's Ghat, for the fall is slight in the whole distance that the

back-water would soon spill over into them. The whole area is 270 acres.

24. The area enclosed by the Race Course is naturally pretty well drained, and is high compared with other parts of the Maidan. It is highest round the banks of the Serpentine Tank and slopes outwards all round towards the Race Course. The Encamping ground, on the other hand, enclosed by the loop of the Ellenborough Course, is badly drained, and the new drains will, I hope, have the effect of improving it very much. The present outlet towards Prinsep's Ghat is a wretchedly small one with its floor much above the general level of the drains inside. The consequence of this is that the drains are full of water and the ground very swampy in this neighbourhood all through the rains. I propose using the spoil from the drains and some from the new tanks in joining the angle of the loop of the Ellenborough Course nearest Prinsep's Ghat with the Strand Course Ride, as at present in the rains it is impossible to get from one to the other without wading through water up to the girths.

25. With regard to the other lines of drainage it is not necessary to say much, as they require little to be done to them in the way of reformation. The area tinted pink round the Dhurum-tollah Tank is shewn in the plan as discharging into the sewer under Esplanade Row, but practically the whole discharge will be taken up by the tank, and it will be very rarely that any will spill from thence into the sewer. There will be no harm, therefore, in throwing this work on the sewers, although, as I have mentioned above, they are not intended to take any of the Maidan Drainage. The ground opposite the Town Hall at present also drains into the same sewer, and it is not worth while disturbing it until it is shewn to be necessary, although, to be in the safe side, I have provided for draining it into the main trunk line No. 1. The alterations in these small drainage areas are not like the work on the main lines, definite and capable of being described and estimated beforehand, but like that required in the formation of the feeder drains and surface slopes, which I think can only be done satisfactorily by means of a good Nokur Cooly Establishment well supervised, and which I am accordingly about to propose.

26. In paragraph 7 I proposed to consider the drainage in two ways; first, the construction of trunk and branch drains, which have been considered in the preceding paragraphs; and secondly, the adjustment of the surface of the ground into such slopes as shall throw the water quickly into the drains. This part of the subject will naturally have more of the nature of a landscape gardener's work than an Engineer's, and I do not know how to do it more efficiently than by keeping a fixed establishment of coolies constantly at it till the surface of the Maidan has been thoroughly put into proper order. I do not propose to make the feeder drains by digging trenches, of which there will be quite as many as it is advisable to allow in the trunk drains, but by cutting away the ground on the banks of the main drains and throwing it back to wherever it appears to be required, so as to form a succession of very slight undulations, so slight as to be scarcely perceptible and yet sufficient to prevent the water from lying on the ground. This would be a very expensive and tedious work if the whole of the Maidan had to be done; but fortunately many parts have already got a tolerable

inclination, and the new sloping will be confined to those parts which are now swampy, and which may be distinguished by a darker color in the grass as well as by the deep foot prints of the cattle left in them. I anticipate that about 100 coolies a day for the next ten months, or till about the close of next rains will be able to do the work, and I have accordingly provided about Rupees 5,000 in the estimate. I intend to use the earth from the new trunk being dug for the Fort water-supply, as far as possible, in this work; but it is a question whether it would not be worth while for the improvement of the Maidan to dig an additional tank or enlarge some of the existing tanks for the sake of the earth to be used in raising the low ground as well as for providing a fine piece of water. I have suggested to the Commissioner of Police the idea of joining the Dhoba Pookur Tank with the one close to the west of it in an irregular fashion, such as that sketched in dotted lines on the plan: This would produce a splendid sheet of water, and the earth excavated from it could be used in giving the neighbouring part of the Maidan an undulating park-like effect if planted with trees and laid out with a few garden paths and occasional clumps of flowering shrubs. The impure water at present in these tanks would be pumped out and the lake formed by them kept clean afterwards for drinking purposes, till superseded by the completion of the Calcutta Water-supply, when it might be given up for an ornamental water and for boating, &c. The first cost of this work would be about Rupees 50,000.

27. The following is an estimate of the cost of the Drainage works I have recommended the detailed estimates and plans for the several bridges will be submitted separately as the are prepared, but it appears inadvisable to delay this Report for them. The estimate now

given may be relied on, and it is not the less intelligible for want of more details. It will be seen that the chief expense is in the bridges as would be expected. Of these there are 23 costing Rupees 62,454 in the aggregate. The most expensive of them will cost Rupees 14,700, and the least Rupees 100. There is not one of them whose re-construction could have been saved by adopting a smaller rainfall than that assumed by me. And it will be seen from the Table on the plan that, assuming the same section of drain as there shewn to be adopted for any smaller rainfall than 12", the spans of the bridges by no means decrease in the same ratio as the discharges, and their cost would decrease even in a in a less ratio still. For instance, a bridge of 16.45 feet waterway, like that under the Strand on main drain No. 1, would be reduced only to 12.07 feet if the discharge were halved, and the cost would go down from about Rupees 14,700 to 12,900, or 26 per cent in the one case against only 12½ per cent in the other. And this is taking the most favorable case, for as the bridges get smaller the reduction gets almost inappreciable. I do not anticipate therefore that the whole saving in the project, if it had been prepared for a 6" rainfall instead of 12", would have been more than Rupees 5,000 or 6,000, and the diminished velocity and power of discharge in the drains would have been, in my opinion, a great sacrifice for so small a gain. Of course, the section of the drains might be altered so as to give it a greater hydraulic mean depth, and therefore a greater comparative velocity and discharge, and the spans of the bridges could thus be made to vary directly with the rainfall, but the objection in this case would lie in the side slopes of the drains becoming too steep and trench-like. I feel confident therefore in recommending the execution of the drainage as I have projected it:—

#### Estimate.

Items of charge.	Quantity.	Rate.	Cost.	Total.	Grand Total.
Earth-work in excavation of drains as per Schedule ...	16,10,850	1 Re 3 100	16,100		
Drain Bridges as per Schedule ...	...	...	62,454		
Re-forming section, &c., of the Peepul-puttee drain, including cartage of brick-rubbish from old building in General Hospital ...	...	...	4,000		
				82,563	
Add contingencies at 5 per cent ...	...	...	...	4,128	
<b>Total Rupees</b> ...	...	...			<b>86,691</b>

### Schedule of Earth-work.

Designation of Drains.	Length.	Average Section 102.	Contents.	Total.	Grand Total.
Main Drain No. 1 ... ..	7,700	40	3,08,000		
Ditto " 2 ... ..	7,900	40	3,16,000		
Ditto " 3 ... ..	7,700	40	3,08,000		
				<hr/>	
				9,32,000	
Add 50 per cent for the feeders and surface dressing, as alluded to in the Report, to cover cost of establishment	.....	.....	.....		
				4,66,000	
Main Drain No. 4 ... ..	2,100	22.5			
Ditto " 5 ... ..	2,700	22.5			
Ditto " 6 ... ..	2,300	22.5			
Ditto " 7 ... ..	1,500	22.5			
	<hr/>				
	8,600	22.5	1,98,500		
Add 10 per cent for the feeders	.....	.....	19,850		
				<hr/>	
				2,12,850	
	<hr/>				
Total cubic feet	.....	.....	.....	.....	16,10,850

### Schedule of Bridges.

Drain over which the Bridge has to be built.	Road on which the Bridge has to be built.	No. of Arches.	Span of each Arch.	Height of Abutment up to springing.	Length of Bridge in feet.	Cost.	Total of each Drain.
						Rs.	Rs.
Main Drain No. 1	The Strand...	1	16-45	2' 6"	129	14,700	30,846
	Calcutta Gate Road	1	15-9	2' 5"	20	2,275	
	Plassey " "	1	13-71	2' 1"	20	2,008	
	Ellenborough Course	3	5-34	1' 9"	112	1,381	
	Main Course, with the Secretary's Walk	2	6	1' 8"	164	5,094	
	Jaun Bazar Cross	2	5	1' 6"	45	1,588	
	Chowringhee Road...	1	6-58	1' 0"	125	2,700	
Branch O P of Drain No. 1	Bentinck Road	1	5-5	0' 10"	60	900	7,213
	Sortie Bridge	1	3	0' 6"	20	100	
	Ditto ditto	1	3	0' 6"	20	100	
Main Drain No. 2	Dhoba Pookur Road	2	4	1' 2"	11-5	300	4,238
	Lower Circular Road	2	7	2' 2"	92	4,238	
Branch B G of Drain No. 2	Hospital Road	1	7-13	1' 1"	92	2,825	7,213
Branch K N of Drain No. 2	Jail Cross	1	3	0' 6"	70	350	
Main Drain No. 3	Kidderpore Road	1	6	0' 11"	100	2,000	24,395
	Ellenborough Course, No. 1	1	7-68	1' 2"	103	2,575	
	Ditto ditto " 2	3	5	2' 2"	110	4,400	
	Cross Road " 1	3	5	2' 2"	40	1,600	
	Ditto " 2	3	5	2' 3"	30	1,200	
	The Strand...	3	5	2' 3"	260	10,400	
Branch H G of Drain No. 4	Kidderpore Road	1	5	0' 9"	108	1,620	24,395
	Race Course	1	4½	0' 8"	60	600	
Total Rs.		...	...	...	...	...	62,454



Extracts from a letter from LIEUTENANT-COLONEL J. P. BEADLE, R. E., Secretary to the Government of Bengal in the Public Works Department, to the Superintending Engineer of the Presidency Circle,—(No. 697, dated the 13th February 1865.)

2. THIS project, which embraces the works

According to Estimate and Schedules attached to the Report.

	Cost.
Excavation of Main Drains and	Rs. 10,190
Fellers with surface dressing ...	62,454
Twenty-two Drain Bridges ...	
Re-forming Section, &c., of the	
Peepulputtee Drain ...	4,000
Contingencies at 5 per cent ...	4,128
Total Rs. ...	86,691

Governor, and I am desired, in communicating sanction to the whole outlay involved in it, viz. Rupees (86,691) eighty-six thousand six hundred and ninety-one, to state that the Garrison Engineer should proceed as fast as possible with the project to completion.

3. The above outlay will be met from the Local Funds\* in the hands of the Commissioner of Police of Calcutta, and provision has been made for it in the Public Works Budget for 1865-66 (see Item No. 121, Local, Pages 14 and 15) to the extent of Rupees 36,606, the difference between this sum

and the total estimated outlay, or Rupees 50,085, having been computed as the expenditure up to the end of this year, or 30th April next.

4. In regard to the proposal for laying out the ground in the vicinity of the tank north of the Jail, recommended in paragraph 26 of Captain Trevor's Report, I am to state that the Commissioner of Police will be called upon to report whether he would recommend that this work can be carried out, excepting the walks and shrubs, which, in the Lieutenant-Governor's opinion, may be postponed at a further outlay of Rupees 50,000.

5. The attention of the Suburban Municipality will be called to the remarks contained in paragraph 19 of the Report regarding the continuation of the Peepulputtee outlet drain.

6. The Lieutenant-Governor considers it expedient that the lane proposed by Captain Trevor to the east of the General Hospital and opening from the Lower Circular Road to the Peepulputtee Road should be formed, and a further detailed report on this proposal shewing the cost is required.

8. Agreeably with the suggestion made in the last paragraph of your letter, Captain Trevor's report will be published in the Supplement to the Calcutta Gazette.



## SUPPLEMENT TO The Calcutta Gazette.

WEDNESDAY, MARCH 22, 1865.

### OFFICIAL PAPERS.

A SUPPLEMENT to the GAZETTE will henceforward be published, containing such Official Papers and Information as the Government of Bengal may deem to be of interest to the Public, and such as may usefully be made known.

Non-Subscribers to the GAZETTE may receive the SUPPLEMENT separately on a payment of six Rupees per annum if delivered in Calcutta, or twelve Rupees if sent by Post.

No Official Orders or Notifications, the publication of which in the GAZETTE is required by Law, or which it has been customary to publish in the GAZETTE, will be included in the SUPPLEMENT. For such Orders and Notifications the body of the GAZETTE must be looked to as heretofore.

#### Calcutta Water-Supply.

From R. TURNBULL, Esq., Secretary to the Justices of the Peace for the Town of Calcutta, to the Secretary to the Government of Bengal,—(No. 124, dated the 9th February 1865.)

I HAVE the honor, by direction of the Chairman of the Justices, to forward copy of a Report on a "supply of water for the Town of Calcutta" which has been prepared by the Engineer to the Justices.

2. This Report was first considered by the Water-supply Committee, who passed the following Resolution:—

"The Water-supply Committee desire to record their high sense of the value of Mr. Clark's services as shewn in the Report and project. It is a complete and matured scheme and evidences fully the knowledge and ability of Mr. Clark, and the advantage which he has taken of the opportunities which were recently afforded him in a visit to England. The Committee believe that this scheme is as perfect as any scheme can be, and that it is based on the soundest principles, the most approved practice, and on the most recent experience. The Committee, therefore, recommend its adoption in its entirety, and they, moreover, believe that it can be carried out within the estimated cost.

"The Committee are of opinion that the carrying out of the scheme ought not to be placed in the hands of any Water Company, but that the works should be carried out by contract under the supervision of the Justices."

3. The Report was then considered by the Finance Committee with a view to determine the manner in which the funds required to carry out the scheme of the Engineer should be provided, when it was resolved, that—

"The Finance Committee concur in the opinion expressed by the Water-supply Committee as

regards the manner in which the Water-supply for Calcutta should be carried out.

"The Committee are of opinion that the amount required for completion of the Water-supply works should be raised by loan; that ten lacs out of the sum to the credit of the Water-supply Fund should be reserved for the payment of interest on such loan pending the completion of such works; and that Act VI. of 1863 should be amended, so as to render it compulsory on the Justices to impose, at the completion of the works, such an annual water-rate as shall cover the payment of the interest on the Water-supply loan, of the current expenses and maintenance and depreciation of the works, less such sum as may be obtained by sale of the water.

"The Committee also concur in the opinion of the Committee on Water-supply that the works should be carried out by contract under supervision of the Justices."

4. Finally the Report was laid, together with the recommendations of the Water-supply and of the Finance Committees, before the Justices in meeting on the 6th instant, and it was resolved that—

"The Justices, concurring in the opinion expressed by the Water-supply and Finance Committees, adopt the scheme which has been prepared by their Engineer for the supply of the Town of Calcutta with water, and authorize the Chairman, subject to the sanction of His Honor the Lieutenant-Governor of Bengal, under Section XXXIII. of Act VI. (B. C.) of 1863, to carry out the scheme in accordance with the recommendations of the abovenamed Committees."

5. In applying for the sanction of His Honor the Lieutenant-Governor, the Chairman desires to submit, for His Honor's consideration, a few observations on one or two points connected with the scheme and the recommendations of the Committees.

6. A sum of Rupees ten lacs towards a Water-supply Fund has been contributed by the Govern-

ment out of the Income Tax collections in Calcutta, and this sum will, with the contribution for the current year, and accumulated interest during the next four years, aggregate at the utmost fifteen lacs of Rupees.

7. Recourse must therefore be had to a loan to meet the cost of the scheme.

8. If the entire sum to the credit of the Water-supply Fund were appropriated towards that cost, an additional sum of Rupees 42,00,000 must be raised, and the current interest on it will have to be met by additional taxation.

9. As the present rate-payers have already been taxed for the Income Tax, (from which the Water-supply Fund is created,) and as they will derive no benefit from the Water-supply works pending their completion, it is considered unjust to impose a second Tax to meet the interest of the loan during that period, and it is therefore proposed that a loan of fifty lacs should be raised as required, and that ten lacs of Rupees should be set aside out of the Water-supply Fund to meet the interest accruing on that loan for the four or five years within which the works of the Water-supply should be brought into operation.

10. Thus the scheme will be carried out without the necessity of imposing an additional Tax until the system of Water-supply is declared to be complete in accordance with Section LXI. of Act VI. of 1863.

11. Before that period, however, arrives it will be necessary to make provision for the payment of interest, as well as for the cost of the annual working expenses, and for the depreciation of the stock and plant, and as the general Fund could not possibly bear such additional burden, it would be desirable that the manner in which it is intended to make such provision be at once declared and rendered compulsory by law.

12. It is with this view, therefore, that the Financial Committee recommended, and the Justices in meeting have adopted the recommendation, that "Section LXI. of Act VI. of 1863 should be amended so as to render it compulsory on the Justices to enforce, at the completion of the works, such an annual water-rate as shall cover the payment of the interests on the Water-supply loan, of the current expenses, maintenance and depreciation of the works, less such sum as may be obtained by the sale of the water."

13. The Section thus amended would read as follows:—

"The Justices shall carry out a system for the supply of water within the Town, and shall, for that purpose, cause such pipes to be laid, and such tanks, reservoirs, and other works to be made and constructed, as shall be necessary. Such supply shall be deemed, for the purposes of this Act, to be complete within the Town so soon as the Justices shall have, with the sanction of the Lieutenant-Governor of Bengal, declared, by Notification published in the *Government Gazette*, that the supply is complete within the Town. So soon as the supply shall be complete within the Town the Justices shall impose an annual water-rate on the assessed value of all houses, buildings, and lands in the Town, and such water-rate shall be determined in such a manner that the gross proceeds thereof shall be sufficient and no more to cover the annual interest payable on any loans which might have been raised for the construction of the Water-supply works, as well as to cover the payment of

the current working expenses, and the maintenance and depreciation of the stock and plant, less such sum as may be realized by the sale of the water, and such rate shall be assessed in the manner hereinafter described."

14. This amendment of the law should be effected, if possible, simultaneously with the sanction of the scheme.

15. As it is of the utmost importance that no delay should be allowed to occur in the execution of these works, (when sanctioned,) the Chairman submits Declarations, under the Section II. of Act VI. of 1857, for the land required to be purchased at Pulta, Tallah, and Wellington Square for the construction of the water-works, and trusts that they may be approved and published in the *Government Gazette* as soon as possible.

16. It has been found necessary to seek the aid of Government in enforcing the sale of these lands on account of the nature of the titles connected with them, which preclude their purchase by private arrangement, and the Justices are bound to secure a valid and unassailable title for these lands before constructing works of such cost as these, and this can only be done by recourse to Act VI. of 1857.

*Extract from the Proceedings of the Water-supply and Finance Committees.*

## WATER-SUPPLY

*The 30th January 1865.*

### PRESENT:

THE Chairman and Vice-Chairman, Colonel Beadle, R. E., Captain Hyde, and Messrs. F. Jennings and W. Haworth.

"The Water-supply Committee desire to record their high sense of the value of Mr. Clark's services as shewn in this Report and project. It is a complete and matured scheme, and evidences fully the knowledge and ability of Mr. Clark, and the advantage which he has taken of the opportunities which were recently afforded him in a visit to England. The Committee believe that this scheme is as perfect as any scheme can be, and that it is based on the soundest principles, the most approved practice, and on the most recent experience. The Committee therefore recommend its adoption in its entirety, and they moreover believe that it can be carried out within the estimated cost."

2. The Committee are of opinion that the carrying out of the scheme ought not to be placed in the hands of any Water Company, but that the works should be carried out by contract under the supervision of the Justices.

## FINANCE.

*The 2nd February 1865.*

### PRESENT:

The Chairman and Vice-Chairman, Colonel Beadle R. E., Messrs. H. G. Dunlop, J. B. Roberts, J. B. Knight, and Ramgopal Ghose.

The Finance Committee concur in the opinion expressed by the Water-supply Committee a



regards the manner in which the Water-supply for Calcutta should be carried out.

The Committee are of opinion that the amount required for the completion of the Water-supply works should be raised by loan; that of the sum to the credit of the Water-supply Funds ten lakhs should be reserved for the payment of interest on such loan pending the completion of the works, and that Section LXI. of Act VI. of 1863 should be amended, so as to render it compulsory on the Justices to enforce, at the completion of the works, such an Annual Water-rate as shall cover the payment of the interest on the Water supply loan, of the current expenses, maintenance and depreciation of the works, less such sum as may be obtained by sale of the water.

From W. CLARK, Esq., Engineer to the Justices, to V. H. SCHALCH, Esq., Chairman to the Justices of the Peace, Calcutta,—(dated the 20th January 1865.)

I HAVE the honor to lay before you my Report on the works which should be undertaken for supplying the City of Calcutta with water, and in doing so, I propose to confine my observations entirely to the Engineering points of the question, as it appears unnecessary for me to enter again into those which have been recently discussed, though having an important bearing on this subject.

I refer more particularly to the source of supply as well as to the means for defraying the first cost and after working expenses.

2. The source of supply has been fully considered in a recent paper by the Bengal Sanitary Commission, and the weight of the opinion, confirming as it does the conclusion previously arrived at, *viz.* that there is practically no other available source of supply than the River Hooghly, must be considered decisive.

3. The experiments and analysis of the water taken from various places on the river has enabled Dr Macnamara to fix on Pulta as the point from which the water may be taken, and, considering the various causes of contamination to which the river is subject, its muddy and uninviting appearance as a source from whence to derive a supply for domestic purposes, it is satisfactory to read the opinion of a Chemist, "that with proper management the river at Pulta will yield a fairly good Water-supply, and I believe the supply might, by the use of Spencer's Filter, be made almost unexceptionable."

Thus far the preliminary enquiries have been settled.

4. With reference to the financial part of the subject, *viz.* the amount of money requisite for the construction of the works, I may remark that the Estimate for those which I now propose is largely in excess of that which I have made in a previous Report, and it is necessary to state that the works then contemplated were intended rather to correspond with the Funds available than the requirements which an Engineer, if unfettered by limited funds, (six and a half lacs of Rupees,) would have estimated for.

There was, however, no part of that scheme which could not have been made available in the more perfect works I now recommend for adoption.

5. The rejection of Cossipore as the spot from which the water should be taken, and the adoption of a point 12 miles higher up the river, of itself necessitate a largely increased estimate.

6. The working expenses of the present scheme also will be in excess of what was then proposed.

It must, however, be born in mind that these more perfect and expensive works are intended to give double the supply,—*ix.*, instead of three million gallons per day.

7. The levels of the country shew that the surface of the central road (College and Cornwallis Street) between Wellington Square and the Canal varies between 19 and 24 feet above datum (Kidderpore Dock Sill); to the north of the Canal at Tallah the average level of the ground is 18 feet, and from thence, with slight undulations, the surface rises to an average level of 30 feet above datum by the river side at Pulta.

This gradual rise of the surface, about 11½ inches per mile, admits of the construction of an aqueduct between Pulta and Tallah, with no other difficulties than those attendant upon a soft silty soil saturated with water.

8. The straight direction of the Barrackpore road for the greater part of the distance towards the point where the works will be established by the river side affords great facilities for the construction of any form of conduit which may be decided on. The sanction of the Government to placing it outside the avenue of trees on the east side of the road being alone necessary.

9. The two alternatives are a brickwork or an iron conduit.

I believe a 27-inch main pipe could be laid more quickly and at a somewhat less cost than brickwork; this, however, would render increased engine power necessary at Pulta to drive the water through the pipe, and the additional working expenses due to the lifting of the entire quantity, 6 million gallons per day, to the height of 100 feet.

With a brick aqueduct this expense will be entirely unnecessary.

10. Moreover, the shorter life, or duration, of an iron pipe in this country, owing to the saline nature of the soil, is a matter for grave consideration.

Mr. Mellor, the Engineer of the Oriental Gas Company, who has the best experience in this subject, estimates the depreciation of iron pipes from this cause at not less than 4 per cent. per annum.

11. Brickwork, on the other hand, of first rate quality may be regarded as indestructible.

The repairs and depreciation of a masonry aqueduct will be inversely as the care and skill exercised on its construction.

12. After a careful consideration of all the circumstances of the case, I propose to adopt a conduit constructed of brickwork, 66,600 feet in length, between Pulta and Tallah, laid at the inclination I have named, *viz.* 1 in 5,500.

That the water shall be received in a covered tank at the latter place, and the engines and pipes for supplying the Northern Division of the Town shall there commence.

13. I consider, moreover, that, as the aqueduct will require occasional cleaning and repair, it should be made rather larger than one-half the size required for the total prospective supply of 12 million gallons.

That in the event of an extension of the works being required to distribute that quantity a second aqueduct should be then constructed, so as to avoid the stoppages and contingencies which a dependance on one channel necessitates.

14. With this view I propose that the aqueduct first constructed shall be capable of conveying, by a constantly running stream, 9 million gallons per twenty-four hours from the filters at Pulta to the reservoir at Tallah.

15. On the determination of these leading points the arrangement of the entire works for pumping the water and its distribution have mainly depended.

16. There has been some delay in deciding on the best of the several routes at the northern end of the line, where the aqueduct leaves the Trunk Road, eventually that passing through Barrackpore Cantonments has been decided on.

17. The levels have been taken by persons previously unconnected with the office, have been checked and are believed to be correct, but it will be very necessary, before the works are commenced, to go over them again by another and competent person to ensure there being no discrepancy in this vital part of the question.

18. I have, with as much despatch as my state of health has permitted, prepared Plans and Sections shewing the general arrangement of the works, and sufficient detailed drawings, &c., to enable me to form an estimate of their extent and cost.

19. The works are intended to distribute in Calcutta, immediately on their completion, 6 million gallons per day, and they are all designed with a view to an extension so as to supply 12 million gallons when a demand for the extra quantity shall appear.

20. Their general arrangement will be understood from the Diagram, page 31, and Plan No. I. The works at Pulta to be first undertaken comprise all that is necessary to cleanse, filter, and discharge into the aqueduct 7 million gallons per day, with a spare area in the settling beds and filters to allow of their proper cleansing and repair.

21. The site of these works is  $2\frac{1}{2}$  miles to the north of Government House at Barrackpore, and 29,000 yards or about  $16\frac{1}{2}$  miles from Wellington Square in Calcutta.

22. The water will be pumped up from the river twice in the day during five hours at each period of low water. It will be conveyed by the river water aqueduct to the settling tanks, of which there will be four at first provided.

23. The water will there remain quiescent for a period of thirty-six hours, after which it will be drawn off from the surface into the filter by the clear water culvert.

24. The water will sink through the filtering medium and be received by a culvert, which will convey it into the aqueduct leading to Tallah, from which it will be received in a covered reservoir.

25. It may here be remarked that the aqueduct could not be carried further with economy, the extra depth would largely increase the cost and difficulty of its construction, and a risk of contamination by proximity to sewers, &c., in the city would be incurred.

26. The Engines will be erected at Tallah in close proximity to the covered reservoir for the purpose of lifting the water to a sufficient elevation to distribute half the entire quantity, viz. 3 million gallons in the Northern Division of the town during the day time, under a pressure of 50 feet at the works, and during the hours of night

to deliver 3 million gallons into a covered reservoir to be constructed in Wellington Square.

27. Adjacent to the Wellington Square reservoir engines will be erected to distribute water under a pressure of 100 feet to the European and Mercantile portion of the city, where high service will be required, and to the shipping laying along the river bank.

28. The proximity of the works to two important Military Stations, Barrackpore and Dum-Dum, affords great facilities for extending to them the benefit of a pure Water-supply, and I have therefore prepared estimates for delivering 120,000 gallons per day to Barrackpore, and half that quantity to Dum-Dum.

29. The muddy character of the water to be dealt with is an unusual feature in works of this description and necessitates peculiar and special arrangements being provided.

The amount of solid matter in suspension has been variously estimated.

Dr. Macnamara's experiments shew that it varied between  $\frac{1}{100}$  and  $\frac{1}{1000}$ th part of dried solid by cubic measurement.

30. In 6 million gallons of water the former proportion gives 428, and the latter 2,700 cubic feet of dried solid matter as a daily quantity to be abstracted from the water during the process of cleansing.

31. According to the experiments of the late Mr. Piddington, who made special enquiries into this subject, the amount of dried solid may be generally estimated at one cubic inch in one cubic foot of water, or  $\frac{1}{1728}$ th part.

32. As, however, this deposit will require to be removed in its fluid state of soft mud, it may be roughly estimated that a quantity of not less than 4,000 to 5,000 cubic feet of this mud will require to be removed per day from the Pulta works.

33. The only effectual means to be adopted for the first process of cleansing is the simple one of allowing the muddy particles to *subside* through the water in preference to that of *straining* by which the water is drawn through the mud, as it is highly probable that, while extracting the mechanical impurities, those in solution may be increased by bringing the water into more immediate contact with the sedimentary matter.

34. Dr. Macnamara, speaking of the physical properties of the water, states: "During the rains though the grosser mechanical impurities can be readily separated by filtration or subsidence, but there still remains in suspension very finely divided clayey matter which gives the water a turbid appearance."

"This impurity cannot be separated by filtration, and it requires some seven or eight days to subside completely. Moreover, the slightest agitation is sufficient to stir up the sediment; during the remainder of the year the mechanical impurities can be readily and completely separated by subsidence or filtration. Twenty-four hours is sufficient to effect the clearance by subsidence."

35. On the completeness of this process of cleansing by subsidence will the purity of the supply mainly depend, for if the water be admitted to the filters in its muddy state the latter will speedily become coated with mud, and the soluble impurities contained therein (as I have above attempted to describe) would be

imparted to the water in its downward course through the filter.

To obviate this difficulty in my former Report I proposed to adopt the plan of *upward* filtration.

35. During my recent visit to England I made special enquiries on this point, and visited water-works where various arrangements had been proposed, *viz.* where upward, downward, and the Scotch system of triple filtration had been tried.

I found, however, that filters originally intended for the upward process, as well as the triple system, had disappeared, and, so far as I could learn, the general practice is to use the downward process, and the most recent examples of these works are all so arranged.

The difficulty in cleansing the under channels for the upward process had been found so great, that it had been abandoned and the downward process substituted.

36. Subsequent to the above extract from Dr. Macnamara's Report in his letter dated 19th July 1864, after having experimented with Spencer's Filter, he states that, "besides diminishing the organic matter, it entirely removes the suspended matter, rendering the water, even in the rains, perfectly clear and bright, and I think it probable that by the use of the Magnetic Carbide of *proper thickness* the dissolved organic matter might be got rid of."

37. It is evident that though the means are procurable for purifying the muddy water of the Hooghly by the process of filtration, every possible care should be observed in cleansing the water, as far as practicable, by subsidence.

38. It is therefore proposed in these works to provide an unusually large area of settling tanks, and that the water shall, after being pumped into these receptacles, remain for a period of thirty-six hours absolutely quiescent, and then to be drawn off from the surface only by an arrangement especially adapted for the purpose without causing any current or disturbance of the water.

39. The filters will be divided into compartments of 100 by 200 feet, so as to permit their frequent cleansing, by scraping off from the top about  $\frac{3}{4}$  inch, so as to expose a fresh surface of clean sand.

A sand-washing apparatus will also be provided.

40. I propose now to notice in some detail the various parts of the works which are comprised in this scheme.

They will commence at the river side by the construction of a screw pile jetty shewn in the Drawing No. 3, taken so far into the river as to allow a depth of 10 feet at low water at the river end for convenience of boats discharging coal, &c., for the works.

The river bank at the point selected is very favorable, within a distance of 100 feet from low water mark a depth of 60 feet is attained, which increases to 70 feet at a distance of 140 feet.

41. It will be very desirable, should these works be decided on, to construct the jetty as early as practicable, so that the machinery and materials may be landed without difficulty.

42. The jetty will be about 100 feet long, 20 feet wide, and T shaped at the end, with a travelling crane running on a tramway capable of lifting 5 tons.

The jetty will also protect the suction pipe attached to the pumps at its river extremity.

43. From the extremity of the jetty a double line of tramway will be laid to the coal shed, and from thence a single line will extend round the filters for the conveyance of sand to the washing machine and its re-distribution after cleansing.

44. The engines will be three in number, all precisely similar to each other, 50 horse power, any two of them capable of lifting the daily supply from the level of extreme low water to that of the settling tanks, a total lift of 31 feet in ten hours.

The engines will be double acting, high pressure, expansive, and condensing.

Four boilers will be fixed for working these engines, each of them capable of working one of the engines; proper coal sheds, &c., adjacent to the boiler house will be provided capable of containing one month's supply of coals.

Each engine will be attached to a plunger pump of the ordinary description capable of lifting the quantity of water before alluded to, and a smaller pump capable of lifting water to an elevation of 50 feet above the surface of the ground for supply of Barrackpore.

45. The water, as it leaves the pumps, will be conveyed along an open channel, the river water aqueduct, 7 feet wide, built about 1 foot below the present surface of the ground (which will be raised 6 or 7 feet) and connected with the four settling tanks by a series of valves, about 50 feet apart, fixed in the side thereof, as shewn in the Drawing No. 4.

Each of these inlets will be protected by two valves, one at either end of the inlet pipe (1 foot 3 inches diameter) to control the admission of water as may be required, and each of these pipes will enter the settling tank at the level of the floor.

46. The settling tanks will be four in number, each 500 feet square.

The bottom of these tanks and foundations of the walls will be constructed 2 to 4 feet below the present surface of the ground.

Each tank will be contained by four vertical walls, and divided by a partition wall strengthened by counterforts, so as to be able to withstand the pressure when either half of the tanks is full and the other empty.

Two tanks, each 500 by 250 feet, will thus be formed.

The object of this is to diminish the area of settling tanks thrown out of use during the process of cleansing.

47. It is intended that the engines shall fill these tanks to a level of 36 feet above datum. The containing walls will be about 6 feet above the present surface level, the tanks will be 7 feet deep at the upper, and 9 feet deep at the lower end.

48. After standing thirty-six hours the water will be drawn off from the surface as it descends to a depth of 4 feet and allowed to run through the clear water culvert to the filters; at a depth of 4 feet, and after 1 million cubic feet has been run off, the escape to the filters will be stopped, the lower 3 to 5 feet will remain in the tank till it is again filled, or a portion of it may be run off into another division of the settling tanks where cleansing is in progress.

49. The admission of the water at the floor level at the upper end of the tank will cause the mud to accumulate at the lower or opposite end, and thereby ensure that the upper end, from

which the water is allowed to escape to the filters, shall be the purest part of the tank.

For the purpose of cleansing, the bottoms of the settling tanks are arranged in a series of corrugations as shewn in the Plan No. 4; on each of the ridges a shallow drain 4 feet wide by 1 foot 3 inches deep will be formed, into one of which each of the pipes from the river water aqueduct will be made to discharge.

50. At the opposite or lower end of the tank and level with the floor apertures protected by sluices will be formed in each of the valleys, from which the muddy water collected in the tank will be allowed to escape.

The fall of the floor between the upper and lower end will be 2 feet in a distance of 500 feet, sufficient inclination to give the water flowing over it a velocity of 150 feet per minute.

51. The object of these arrangements is to cleanse the tanks with the least possible amount of hand labour. It will probably be required after every fourth or fifth filling, and will be as follows:—

52. During the time of high water, when pumping for the day's supply has been discontinued, an engine will pump river water into the tank to be cleaned, admitting it at each one of the six openings consecutively, and in such quantity as may be found necessary to cleanse two sides of the ridge on which the water is flowing. The water will run down the shallow channel as far as may be necessary to temporary dam placed across it, so as to cause the water to flow over portions of the floor of convenient area, and on this area the coolies will be employed to stir up the deposit, the water running over it at the same time with considerable velocity will carry away the mud through the lower sluice, it will thus pass off through the sludge culvert (which has an inclination of  $\frac{1}{500}$ ) to the river.

The operation is shewn in the Drawing No. 4, where the temporary dam causes the water to flow over the floor in the direction of the arrows.

Portions of the floor of convenient size may thus be consecutively cleansed with a very small amount of hand labour.

53. In the construction of these tanks, as in every portion of the works intended to hold, or convey water, the greatest care will be necessary to ensure their being water-tight.

The necessity for this precaution will be at once understood when it is known that the surface of water in tanks such as those in Calcutta when nearly full will generally sink 4 inches per day even though no water is taken from them.

The soil of Pulta is of the same character, and doubtless the effect would be similar, it is therefore necessary to make these tanks absolutely water-tight, and the materials, cement, and asphalt will be extensively required for this purpose.

54. The floor will be formed by excavating the earth as nearly as possible to the shape of the corrugations, and covering the whole area with a stratum of concrete 6 inches thick rammed solid to the required shape.

The surface will then be covered with a layer of asphalt half an inch thick, and the whole will be again covered by a brick-on-edge, or 5 inches of brick-work.

55. The containing and division walls will be built with good mortar five inches less in thickness than shewn in the Drawings, but leaving bonding

bricks projecting at intervals of a few feet, the entire surface of the wall will then be plastered with cement, and afterwards the 5 inches in thickness may be carefully built up so as to protect it.

The earth excavated from the filter and settling tanks will be taken to raise the surface of the ground for a width of 100 feet outside, and between the settling tank and filters somewhat above the level of the settling tanks, which will be 36 feet above datum.

56. As before stated, an arrangement is provided for drawing the water off from the surface, decanting it in fact. As the clearest water is always at or near the surface after some time has been allowed for deposit, this will in effect give the water a longer time by twelve hours to settle, and, it is believed, will be of material benefit to the action of the filters in preserving their purity for a longer period.

57. The apparatus for this purpose is very simple, it consists of  $\perp$  shaped tube, the upper end being protected by a wire covering to keep out floating substances.—*Vide* Drawing No. 5.

The outer end of the lower portion of the  $\perp$  will be solid and supported on a plunger block.

The other end will be supported by a tube passing through the wall, the joint between the tubes being made tight by a stuffing box, the whole forming a continuous tube leading into the clear water culvert, but so as to admit of the upper end of the tube being raised or lowered by turning on the two bearings of the lower arm.

The upper end of the  $\perp$  will be attached to two hollow floats of sheet iron and suspended therefrom just so as to keep the orifice immersed to the required depth.

58. As the water surface descends lower and lower, the tube will descend also until the required depth of water is drawn off, which will be regulated by the length of chain from the windlass above.

Should it be found advantageous to draw off the water to a lower level than 4 feet, it will be possible to do so for a further depth of 2 feet by this apparatus.

59. To throw the apparatus out of use, and prevent further escape of the water, will be accomplished by lifting the open and upper end entirely out of the water, and any other sluices in this position will be unnecessary.

60. The water, after passing through the above apparatus, will be received in the clear water culvert, through which it will pass to the filter.

61. The culverts, &c., the flushing or sludge culvert excepted, are all laid with very slight falls, so as to permit the quantity for a full supply of 12 million gallon per day passing through them at a very small velocity, with only sufficient fall to lay them dry when necessary; but all have sufficient height to admit of considerable surface inclination and therefore a high rate of discharge when necessary.

The river water aqueduct has a fall of  $\frac{1}{1000}$ . The clear water culvert  $\frac{1}{1000}$ .

The former will require frequent cleansing, as a considerable quantity of mud may possibly accumulate therein requiring convenience of access.

The clear water culvert, on the other hand, will seldom require cleansing, it will therefore be covered.

It is intended that both of these channels shall be lined with brickwork set in cement.



62. The water will be admitted to the filter through regulating sluices, 2 feet in diameter, one to each compartment, to control the quantity, or shut off any compartment which may be in course of cleansing.

An overflow wall is also provided to spread the in-coming water evenly over the surface of the filter, and prevent any disturbance of the filtering medium.

This arrangement is shewn in Drawing No. 6.

63. The filter will be arranged in eight compartments of 100 x 200 feet each, any one of which may be thrown out of use for the purpose of cleansing, and each compartment will be capable of filtering one million gallons in twenty-four hours.

64. The capacity of the filter will be such as to contain a depth of two feet of water over the filtering material, which will be six feet in thickness, resting on a perforated floor, supported by channels of open brickwork beneath, through which the filtered water will flow into two culverts laid longitudinally down the length of each compartment, and terminating at the lower or opposite end (from that at which the water is admitted) in a well two feet square, up which the filtered water will rise.

From thence it will pass off by short oval culverts 2 feet wide, 3 feet high, protected by a sluice, to the catch water culvert, and thence to the aqueduct leading to Tallah.

65. The bottom of the filter will be constructed in every respect similar to that before described for settling tanks, with a layer of 6 inches of concrete covered by a layer of asphalt and a brick laid on flat over it. Upon this the channels and perforated floor will be formed, so as to permit the passage of the water after descending through the filtering medium; a slight inclination will also be given from the sides towards the culverts.

The outer and division walls of the filter will be vertical and plastered with cement to make them water-tight.

66. The relative levels of the various parts of the works shewn in the Diagram, page 31, give a fall of 2 feet 4 inches from the bottom of the clear water space in the settling tanks to the surface of water in the filter, and a further fall of 2 feet from the surface of the filter to that in the aqueduct leading to Tallah.

The filtering medium will be arranged as follows, commencing from the top:—

Fine sand	...	2' 6" in thickness.
Coarse sand	..	0' 6" " "
Magnetic Carbide	...	0' 6" " "
Coarse sand	...	0' 6" " "
Coarse gravel or shells	..	0' 6" " "
Broken stone	...	1' 6" " "
		6 0

67. The cleansing effect takes place at or near the surface of the filtering medium, and the mud collects there, so that when half or three-quarter inch is scraped off a clean surface of sand is exposed to the action of the water.

After a short period, which is greater or less, as the water is more or less pure, the scraping of the surface must be repeated.

68. The object of the material below (the carbide excepted) is to provide apertures of gradually increasing size to permit the water to escape and detain the filtering material.

69. The use of "magnetic carbide" in filters, is a recent discovery of Mr. Spencer, and its effect, according to the concurrent testimony of Engineers with whom I communicated in England, is highly satisfactory.

For the purpose of testing its use in this country, I brought from England the filter with which Dr. Macnamara has experimented, and his report confirms the favorable opinions of the English Engineers.

70. The Report of the Jury in Class 10, Section B, of the International Exhibition of 1862 is to the following effect:—"The only new material for filtering, and in reality the only novelty in filtration, is that brought forward by Mr. Spencer (United Kingdom, 2403); it is the artificial magnetic oxide of iron. It removes rapidly the peaty matter from solution, and seems to have an action similar to that of charcoal, but more powerful. It is said also to act for years without diminution of force. This is not at all improbable; indeed, we know of no reason why it should diminish in its activity if it is allowed to have free access of air. This is aided by allowing the filter to lie dry for half an hour occasionally according to Mr. Spencer. Before allowing the water to come on this substance it falls on a strainer, so that the oxide does not become choked up in its finer pores. If the filter be small, a sponge will, as usual, answer this purpose; if it be large, such as is used for water-works, a layer of sand above the iron is considered sufficient. This process is said to have been at work at Southport for three years, at the water-works there. It has also been used at one or two other places here and in Ireland, and in one of the Departments of Government. The theory of the action is not quite clear. Mr. Spencer uses magnetic oxide, and also magnetic carbide. The material magnetic oxide has no action, and the carbon of the carbide seems to have no action, as the effect is diminished by its presence. Although some carbon necessarily remains in it from the mode of manufacture, Mr. Spencer believes that ozone is formed, and that the oxidation of the organic materials is hastened thereby. The indications of ozone are very abundant. This filter, as exhibited by Mr. Spencer, is certainly a very powerful agent of purification, and it may be added also, is the only discovery made in this country of a new substance of really great importance for the filtration of water; it is also one of the most important discoveries tending to elucidate the principles of filtration or purification as distinct from mere straining. A medal was given to Mr. Spencer."

71. The arrangements for washing the sand will be equally applicable for cleansing the magnetic carbide, its occasional cleansing and drying as above suggested will be easily accomplished.

72. I believe this material to be similar to the scales which fall from blacksmith's anvils during the process of forging iron, and as this material is easily procurable, it may be useful to know that it can be applied to any domestic filter by placing a layer of it between the layers of sand as ordinarily arranged.

73. The price of the material, Mr. Spencer quotes at £4-10 per ton in England, varying with the price of iron as it is an oxide of that metal.

which Mr. Spencer subjects to some process, by which it is converted into "magnetic carbide."

74. It is possible that the material may be sent as ballast or "dead weight" in ships coming from England, but I consider that it cannot be safely estimated as costing less than £6 per ton delivered at the works in this country.

75. Magnetic oxide of iron, which, I believe, is the material used by Mr. Spencer, is an abundant product in this country, and it will be desirable to enquire at what cost it can be procured and converted into carbide at the Pulta works under arrangements with Mr. Spencer.

76. The layer of carbide in the filter with which Dr. Macnamara experimented is about 6½ inches in thickness.

The usual quantity used in large filters, depending on the greater or less purity of the water, is from 4 to 7 or 8 inches.

77. For the purpose of forming an estimate of the cost of this material for these works, I have calculated for a layer 6 inches in thickness.

I find the weight of the substance in its granulated form to be a little or more than double the weight of water; one cubic foot weighs 135.65 lbs.

78. From these data the cost of this material, at £6 per ton for a filter capable of filtering 8 million gallons per day will be Rs. 2,90,644.

This is a very large sum, but if the certainty of its purifying properties remaining permanently active can be satisfactorily established, I consider the undoubtedly beneficial action of the carbide fully justifies its use, even at this large outlay, nor is there any reason to doubt the permanency of its purifying properties. On this point, however, further enquiries in England are desirable.

79. The filters will, in every other respect, be constructed in the ordinary way, and the application of the carbide would, at any time, be practicable without involving any alteration in the construction of the filter.

80. As before stated the water after leaving the filter will pass through short culverts 2 feet wide, 3 feet high, and 20 feet long to the catch water culvert.

In both of these latter there will be a free surface of water, no upward pressure will be exerted in any of the culverts.

81. The catch water culvert will be 6 feet 11 inches high, 2 feet 9 inches wide at the bottom, and 4 feet wide at springing of covering arch, with sloping sides.

The fall of this culvert is  $\frac{1}{4}$  only, the extra height is intended to allow for any surface inclination necessary.

To ensure this culvert being water-tight, a lining of brickwork in cement is provided in the estimate.

#### AQUEDUCT TO TALLAH.

82. This portion of the work has had my most careful consideration.

The levels of the country are undoubtedly very favorable to the construction of a masonry conduit, it will, however, be a large and expensive work, and will require especial care in its construction to prevent leakage.

83. For the most part the aqueduct will be just below the surface of the ground, and for a short distance only will it be covered by 2 to 3 feet of earth, and the latter depth will, in no case, be exceeded.

The shape will be an oval struck from four centres, the internal dimensions are vertical

height 4 feet 6 inches, and the width 3 feet 6 inches.

84. The quantity of water which this aqueduct will convey at the inclination  $\frac{1}{100}$ , computed by the formula of Eytelwein, Leslie, and Hawkesley, give quantities varying between 8,962,881 to 9,626,500 cubic feet per twenty-four hours when running 3 feet 9 inches deep, which it may do with safety.

85. This capacity for effective discharge will, however, speedily disappear unless an absolute freedom from leakage be insured.

86. The aqueduct for the first 2,900 feet of its length, starting from the Pulta works, will be constructed on private property, which for a width 20 feet must be purchased, and a further width of 30 feet taken for temporary occupation.

87. It will then be carried along the northern boundary of the Barrackpore Cantonment by the side of an existing kuthcha road till it reaches the pukka road leading to Pulta Ghât.

By the side of this latter road it will proceed to a point near where the temporary stables stood lately occupied by the Lahore Light Horse.

Across this part of the parade ground it will be carried for a length of 1,150 feet, the surface of which will for a short distance, 600 feet only, require to be raised one foot.

The construction of the aqueduct will, in no other case, affect the level of the parade ground.

For a short distance (as shewn on the Section) along the public road it will appear at the surface, but in that position will present no obstacles to the use of the parade ground; it will in fact appear like a widening of the road only.

From the parade ground at the point Q on the Plan No. 7 it will take a straight course through the bazar and join the Trunk Road at the corner near the Elephant Shed.

This distance is 200 feet for this length; 20 feet in width, must be purchased, and 30 feet extra taken for temporary occupation.

88. From the Elephant Shed, (Point O on the Plan) the aqueduct will be constructed along the Barrackpore Road to Tallah, except at a bend near the boundary of Tittaghur, where two sharp angles occur.

At this place the aqueduct will pursue a straight course till it again arrives at the position shewn in the cross Sections, viz. about 18 feet from the line of trees on the east side, which is about midway between them and the eastern boundary of the road; at the point of deviation from the Barrackpore Road just alluded to, a further portion of land, 900 feet long and 20 feet wide, must be purchased.

89. Cross sections of the Barrackpore Road, shewing the position and depth of the aqueduct at every 500 feet, are given with the longitudinal section.

90. The aqueduct will leave the Trunk Road at a point 760 yards north of the 4th mile stone from Government House; from this point to Tallah it will proceed across private land for a distance of 185 yards, for which length 20 feet in width must be purchased, and 30 feet taken for temporary occupation, the remainder of the distance will be along a public road to the site of the works at Tallah.

91. The section of the entire line of aqueduct is very favorable; an abstract of the depths of excavation will shew the character of the works:

Between 1 and 2 feet depth of excavation from surface ...	2,500 feet lineal.
Between 2 and 3 feet depth of excavation from surface ...	3,500 "
Between 3 and 4 feet depth of excavation from surface ...	13,850 "
Between 4 and 5 feet depth of excavation from surface ...	15,500 "
Between 5 and 6 feet depth of excavation from surface ...	13,000 "
Between 6 and 7 feet depth of excavation from surface ...	9,500 "
Between 7 and 8 feet depth of excavation from surface ...	7,000 "
Between 8 and 9 feet depth of excavation from surface ..	1,750 "
	<hr/> 66,600

92. Where the excavation is less than 4 feet deep the external section of the aqueduct will be altered, so as to make it self-supporting.

Cross section of the aqueduct at various points of the line in the Barrackpore Road are given in the Drawing No. 8.

93. The section of work for shallow depths has an area of 38 feet 3 inches superficial, while that for greater depths the sectional area is 20 feet only,—Drawing No. 9.

The estimate, however, provides for one-fourth more work in the latter case to cover the extra cost in bad or broken ground.

94. As I have before stated, the brick aqueduct will economise the working expenses due to the lifting of the entire quantity of water, 6 million gallons per day, 100 feet, which would be necessary to drive it through a 27-inch iron pipe.

This economy will, however, only be obtained by making the aqueduct absolutely water-tight.

95. In order to ensure this, I have provided in the estimate for plastering the interior of the aqueduct with cement up to the maximum water line.

96. The thickness of the work under ordinary circumstances will be 15½ inches. After the first two rings 10½ inches in thickness are turned, it is intended to plaster the inner surface with Portland cement, and line the interior with one ring of brickwork in cement, so as to give the internal dimensions desired. If this be carefully done, and the outer surface of the covering arch be asphalted or cemented, I believe the aqueduct may be made perfectly tight.

97. The bricks and other materials for the aqueduct should be of the very best description; and it will be highly desirable to procure for the interior lining a sufficient quantity of the very superior bricks manufactured by Mr. Hickmet at the Government Yard at Akra.

The mortar should be composed of the very best ghosting lime, that can be manufactured, mixed with sorkey of extra fineness and superior quality, and mortar mills worked by machinery should be employed to mix these materials thoroughly.

98. The work should be strengthened in every case when bad or doubtful ground is encountered, as also under the crossing of all roads. A sufficient margin for this is allowed in the estimate.

The interior should be carefully pointed up as the work proceeds; this the height, 4 feet 6 inches, will readily admit of.

99. It will also be highly desirable, during the construction, to test the tightness of the work in every possible way.

This may be done during the rainy season by filling such portions as may be previously completed with water. Temporary dams being erected at such places as will admit of a free discharge of the water when necessary. There are several nullahs crossing the line, which will be suitable for this purpose.

The slightest indication of leakage should be carefully noted and the earliest opportunity taken for its repair.

100. Man-holes with iron covers are also provided at every 500 feet to permit of access for cleansing or repair without breaking the brick-work.

101. Provision must also be made for preventing damage to the aqueduct on the occurrence of any accidental stoppage, by which the accumulation of water and the blowing up of the aqueduct might ensue.

This is proposed to do by the use of cast iron Syphon tubes inserted in the side of the aqueduct, at convenient places on the line, for the escape of the water when it rises above 3 feet 9 inches.

The tubes are to be guarded by a perforated grating at the outer end as an additional precaution, so as to prevent the entrance of vermin, &c.

102. Ventilating shafts will also be provided to allow free ingress and egress of the air, the apertures at the top to be covered with a grating. These arrangements are shewn in the Drawing No. 8.

103. The drainage of the lands and roads along which the aqueduct will be constructed will be provided for by circular culverts; 'Syphons' where necessary; by which the drains and water-courses will be passed under the aqueduct.

104. The works at Tallah will consist of a covered tank with a capacity of eight million gallons, and three engines of 50-horse power each.

105. The covered tank is intended to act as a storage reservoir in cases of emergency should any temporary stoppage occur to the aqueduct, or a larger supply be required than the usual daily quantity on the occasion of fires, &c.

The action of the filter and aqueduct will be uniform and continuous, while that of the engines may vary somewhat with the demand; it is therefore necessary to have a receptacle of considerable capacity in this position.

106. It is necessary that this reservoir should be water-tight, and it is also very desirable that it should be covered, so as to prevent the generation of those impurities which speedily result from the action of light on stagnant water.

It is an axiom with the Engineers of water-works in Europe that the water, after being once filtered, should never subsequently be exposed to the light until it is drawn from the taps for use.

The greater heat of a tropical climate renders this precaution doubly necessary.

107. It is intended to construct two such reservoirs in connection with these works, one at Tallah and the other at Wellington Square.

This construction is shewn in Drawing No. 10, it is a tank with vertical sides 200 x 400 feet in



Plan, its total depth is 20 feet and with a capacity for storing water 16 feet deep; it will hold eight million gallons.

108. The bottom consists of a series of inverted arches 15 feet span, turned on a floor of concrete 6 inches thick, and covered with a layer of asphalt. The inverted arches over this are of two rings of bricks, or 10 inches thick.

Division walls, composed of pillars 3 feet wide, 1 foot 9 inches thick, and separated by arches 7 feet span, stand upon the springing line of the inverts, and from these the covering arches of the reservoir, 15 feet span, are turned.

The outer walls are also arched horizontally, conveying the thrust to the division walls, which act as counterforts.

The end walls of the reservoir are similarly supported by counterforts 1 foot 9 inches thick and 10 feet apart; these also carry the covering arches over this portion of the reservoir.

The outer walls average 2 feet 6 inches thick, and are intended to be plastered with cement to make them water-tight.

109. The engines will be employed for the double duty of discharging the full daily supply for the Southern Division, during the hours of night into the covered reservoir above described, at Wellington Square, and to pump a similar quantity during the day time into the Northern Division. For both these purposes the engines will lift the water under a pressure equal to a column of water 50 feet high.

110. As at Pulta, the engines will be three in number, each 50-horse power, capable of lifting water from the bottom of the reservoir to 50 feet above the surface, and any two of them capable of doing the work required. They will be similar in every respect to those required for Pulta.

For such engines and pumps I obtained tenders during my recent visit to England.

111. Should Canning Town—Mutlah—hereafter require to be supplied from the Calcutta works, Tallah will be the point from which the supply can most easily be given.

112. The water will be conveyed by a 30-inch main pipe extending from the engine to the junction of the Circular Road with Cornwallis Street, so that in the event of a larger supply to the city being required than the 6 million gallons per day, no alteration of this part of the work will be required, as it will admit of two pipes, one 24 and the other 18 inches diameter, being connected with the 30-inch at the above point, so as to keep up a supply to Wellington Square independent of the Northern Division supply.

113. It is intended to carry the 30-inch pipe over, instead of under, the Canal as I formerly proposed; as I find this can be done at the same expense and with less inconvenience, for this purpose the pipe at this part will be of wrought iron curved and tied with iron rods in the form of a bow and string, the pipe resting on two piers one on either side of the Canal near to the bridge, and arranged so as to give a headway for boats, one to two feet higher than that of the Barrackpore bridge itself.

114. From the junction of Cornwallis Street and Circular Road to Wellington Square the pipe will be 24 inches diameter; with this pipe branch or district mains will be connected, each closed by its proper valve.

The various districts are intended to be kept absolutely distinct from each other.

115. Those supplied from the 24-inch Trunk Main between Chitpore and Wellington Square will require to be closed at sunset every evening; on the occurrence of a fire in any one district, by opening the proper valve a supply of water will be at once obtained for a limited area without materially interfering with the supply at the same time being poured into Wellington Square for the use on the following day.

116. The covered reservoir will receive during the night three million gallons for distribution in the European and Mercantile quarters, where two and three-storied houses generally prevail; and any further portion of the total supply of six million gallons which may not at first be required for the Northern Division.

117. The capacity, eight million gallons, is intended to meet any emergency, as the occurrence of a large fire, any unexpected stoppage of the Tallah supply, or necessity for repair which may occur, occupying two or three days. The central position will be highly advantageous for this purpose. The reservoir may be covered with soil and turfed in the usual way, precaution being taken to prevent any surface drainage from entering it.

118. The engine for Wellington Square will be double acting, high pressure, and condensing, with plunger pumps.

The power will be that necessary to distribute the full daily supply from the level of the bottom of the reservoir to a height of 100 feet above the surface, or a total lift of 120 feet in six hours, as during the earlier part of the day, when the draught on the mains may be expected to exceed that of later periods, for this purpose two 75 H. power engines will be required.

I propose to fix three such engines and additional boiler power for this purpose.

119. They will be arranged so as to draw the supply either from the covered reservoir or from the 24-inch main, as may be necessary.

From these engines the water will be at once delivered into the Trunk Mains for the supply of the town.

120. It is highly desirable that the position of the Gas and Water Mains should be subject to some general arrangement, in order to keep them, as far as practicable, apart, as the leakage of gas, where it occurs, is found to be highly prejudicial to water pipes laid in their vicinity; absolute immunity from leakage it is difficult to secure. Generally the position of the pipes in the streets of Calcutta are arranged as follows:—In streets running north and south the Gas Mains are on the east side of the street, while those laid in streets running east and west are on the south sides.

121. The Water Mains will therefore, as a rule, be laid on the opposite side to the foregoing, and either just within, or without, a line drawn along the street dividing off one-fifth of its width as may be most convenient, one-fifth being the average width of foot-paths should such be constructed.

In this position the Water Mains will avoid the Gully Pits constructed for receiving the surface drainage of roads.

#### SCHEME FOR MAIN PIPES.

122. Mr. Mallor, the Engineer to the Gas Company, has very kindly assisted me in the preparation of the scheme; in the following arrangement I am indebted to him for his advice and suggestions.



1st.—A 30-inch Inlet Main from the works at Tella to the Canal Aqueduct, thence to be continued up to Circular Road.

2nd.—A Main 24-inch diameter to be laid from the junction of Circular Road, Cornwallis Street, and Sham Bazar Street to Wellington Square. This Inlet pipe to serve during the day time as a Main to supply the Northern Division of the town at a low pressure, say of 50 feet head, and at night to fill the tank at Wellington Square.

The division of high and low pressure supply to be a line drawn from the Mint to Armenian Street at Chitpore Road, thence extending along Chitpore Road to Lall Bazar, and along Bow Bazar Street to Sealdah.

The north of this to be low pressure.

The south of this to be high pressure.

124. Low Pressure Division.

1st.—The 24-inch Inlet Main as a chief supply.

2nd.—An auxiliary 18-inch Main to be laid along Sham Bazar Street as far as Sobah Bazar, and to be continued with 12-inches along Chitpore Road to Muchoa Bazar Street.

3rd.—A 12-inch Main through Nimtollah Street closeable by one valve at Chitpore Road.

4th.—These Mains to have district service Mains in loops or sections closeable by valves as follows:—

No. 1 Loop, West.—A 6-inch pipe from Upper Chitpore Road along Sobah Bazar Street and Hatcolah to Nimtollah Street, closeable by two valves.

No. 2 Loop, West.—A 6-inch pipe from Upper Chitpore Road along Puttoreah Ghât Street round Durmahatta Street, Strand Road, Nawab Ghât Street, and back by Durmahatta Street to Puttoreah Ghât Street, closeable by two valves at Chitpore Road and Nimtollah Street.

No. 3 Loop, West.—A 4-inch pipe along Rutton Sircar's Garden Street, behind the Mint, 3 inches in Banstollah and Burtollah, and 4 inches in Cotton Street to Chitpore Road, closeable by two valves at Chitpore Road.

No. 4 Loop, Centre.—A 6-inch pipe from the junction of 24-inch and 18-inch pipe, along Bang Bazar to Upper Chitpore Road at Sobah Bazar, closeable by two valves.

No. 5 Loop, Centre.—A 6-inch pipe along Rajah Nobokissen Street from end to end, closeable by two valves.

No. 6 Loop, Centre.—A 6-inch pipe from Chitpore Road at Rajah Gobroodoss' Street to Hindoo College in College Street with 4-inch pipe, in and out from Rajah Gobroodoss' Street, through Manicktollah Street, closeable with two valves at Chitpore Road and Cornwallis Street.

No. 7 Loop, Centre.—A 4-inch pipe in Baranossy Ghose's Street, closeable by two valves, one at each end.

No. 8 Loop, Centre.—A 4-inch pipe along Muchoa Bazar Street, closeable at each end, with two 4-inch valves.

No. 9 Loop, Centre.—A 4-inch pipe through Muchoa Bazar Street from Chitpore Road to Cornwallis Street, along Haladur Street and Cornwallis Street, closeable by three valves at

Chitpore Road, College Street, and Cornwallis Street, having a blank end at Chitpore Road.

No. 10 Loop, East.—Blank for Upper Circular Road.

No. 11 Loop, East.—A 9-inch pipe from Cornwallis Square, through to Circular Road at Kurballah Tank, along Circular Road 6-inch, and back by way of Manicktollah Street east, 4-inch through Cornwallis Square, closeable by two valves.

No. 12 Loop, East.—A 6-inch pipe along Sookes's Street, part of Amherst Street, and East Muchoa Bazar Street, and Circular Road, closeable by two valves.

No. 13 Loop, East.—A 9-inch pipe along Mirzapoor Street, 6-inch in Circular Road, returning 3-inch through the North Gowconnah, and 6-inch by way of Amherst Street closeable by two valves.

125.—HIGH PRESSURE DIVISION.

1st. North, Eastwards.—A 12-inch Main from Engine House along Wellington Street to Bow Bazar, and continued eastwards in Bow Bazar Street to Circular Road at Sealdah.

2nd. Southwards.—A 24-inch chief Trunk Main from engines to Dhurumtollah Street, and continued along Wellesley Street by 18-inch Main to Park Street, thence by 12-inch to Theatre Road.

Lateral main branches from the above to be as follows:—

3rd. Westwards.—An 18-inch Main from Wellesley Street along Dhurumtollah Street, and Esplanade Row to Government House, continued through the Government House Compound by 12-inch to the Strand Road at Chandpal Ghât.

4th. North, Westwards.—A 12-inch Main along Old Court House Street, part of Tank Square, Lall Bazar, and Lower Chitpore Road to Cotton Street, also with branch at the Scotch Kirk along Tank Square and Clive Street to Clive Ghât Street.

5th. South, Westwards.—A 12-inch Main from Wellesley Street along Park Street to Chowringhee Road. This will serve as a supply to the Fort and Maidan when required. A 9-inch Main from Wood Street along Theatre Road to Chowringhee Road.

6th. South, Eastwards.—A 12-inch Main from Wellington Square along Dhurumtollah Street, to Circular Road, and 12-inch on Circular Road to Sealdah. This will serve as a chief supply to the Sewerage Pumping Station if required, and other purposes, and should be laid very deep in the ground.

A 12-inch Main from Wellesley Street along Park Street to Circular Road.

A 9-inch Main from Wood Street along Theatre Road to Circular Road and Chowringhee.

The above will complete the Trunk Mains for chief supply of the Town.

No. 1 Loop, Westward.—A 6-inch Main from Armenian Street at Chitpore Road, to China Bazar Street, 4-inch along Kengree Puttee Street and Kumul Nyam Kaber, Cross Street, part of Old China Bazar to Moorgehatta Street, 6-inch on Strand Road, and returning by 6-inch in Moorgehatta Street, back to Chitpore Road, closeable by two valves, Moorgehatta Street and Armenian Street at Chitpore Road.

No. 2 Loop, West.—A 6-inch pipe from Lall Bazar along Radha Bazar Street, with 4-inch in Dootollah, Pollock, New China Bazar Streets, Lyons' Range, and Swallow Lane, closeable by one valve at Lall Bazar Street.

**No. 3 Loop, West.**—A 6-inch pipe from Fairlie Place along the Strand Road from near Coilah Ghât to Clive Ghât Street, returning by 4-inch in Clive Ghât Street to Clive Street, closeable by two valves in Clive Street, at Fairlie Place and Clive Ghât Street.

**No. 4 Loop, West.**—A 4-inch pipe along Tank Square north, west, and south, Council House Street, Government Place north, and Wellesley Place, closeable by two valves at Government Place, north-east and south-east.

**No. 5 Loop, West.**—A 6-24 to 28-inch pipe from the Treasury Corner, along Government Place west, Hastings' Street, 4-inch in Church Lane, part of Hare Street, Bankshall Street, Coilah Ghât Street, 6-inch along Strand Road to Chandpal Ghât, 4-inch in Old Post Office Street, closeable by three valves, at Chandpal Ghât, Old Post Office Street, and Treasury Corner.

**No. 6 Loop, Centre.**—A 6-inch pipe from College Street, along Bow Bazar to Cossitollah Street, closeable by a valve at each end.

**No. 7 Loop, Centre.**—A 6-inch pipe in Cossitollah Street from Dhurumtollah Street to Lall Bazar, 4-inch in Lall Bazar, Mission Row, and Mangoe Lane, 3-inch round the lower parts of Raneemoodee Gully and Waterloo Street, closeable by one valve at Dhurumtollah Masjid.

*Note.*—Care required that the pipe be not connected at the lower parts of Raneemoodee Gully and Waterloo Street with Loop 8.

**No. 8 Loop, Centre.**—A 4-inch junction at Government Place, north-east, along old Court House Street, to Raneemoodee Gully, Waterloo Street, 3-inch in Crooked Lane and Dacre's Lane, closeable by one valve, opposite Waterloo Street.

*Note.*—The Great Eastern Hotel should be supplied from this.

**No. 9 Loop, Centre.**—A 4-inch pipe along Emambaug Lane, 3-inch Weston's Lane, and round part of Cossitollah Street, to and in Emambara Laffé, 4-inch in Chandnee Choke Street, round part of Dhurumtollah Street to and in Hospital Lane, returning to Emambaug Lane, and closeable by one valve at Wellington Square.

**No. 10 Loop, East.**—A 6-inch pipe from Bow-Bazar Street along St. James' Street, 3-inch along Sakreetollah Lane, part of Wellington Squire, 4-inch in Creek Row, closeable by one valve at St. James' Street, Bow-Bazar.

**No. 11 Loop, East.**—A 6-inch pipe along Jaun Bazar Street, from Wellesley Street to Circular Road, closeable by two valves, one at each end.

**No. 12 Loop, East.**—A 4-inch from Wellesley Square and along the east side, through Kala Chand Lane, and European Asylum Lane to Circular Road, closeable by two valves at the ends.

**No. 13 Loop, East.**—A 9-inch pipe along Circular Road, from Dhurumtollah Street to Theatre Road, closeable by six valves, and acting as an auxiliary Trunk supply.

**No. 14 Loop, East.**—A 8-inch pipe through South Collingah Street, from Wellesley Street to Circular Road, closeable by two valves at the ends.

**No. 15 Loop.**—Elliott's Road and Royd Street 4-inch, two valves.

**No. 16 Loop, East.**—A 6-inch pipe from Park Street through London Street to Robinson Street, with 4-inch pipe in part of Short's Bazar, along Rawdon Street, and remainder of London Street, 3-inch in Theatre Road, Outram, and part of Hungerford Streets, closeable by one valve at London Street, Park Street.

**No. 17 Loop, East.**—A 6-inch pipe from Theatre Road along London Street to Circular Road, where it would be joined by a 6-inch from Theatre Road, along Circular Road, to Hungerford Street, and branches at Auckland Square and Moira Street, closeable by two valves, one at London Street, Theatre Road, and one at Circular Road, Theatre Road.

**No. 18 Loop, South-West.**—A 6-inch pipe along Jaun Bazar Street, from Wellesley Street to Chowringhee Road, thence along Chowringhee Road to Lindsay Street, 4-inch along Lindsay Street and part of Free School Street, with 3-inch branches in Jaun Bazar Lane, closeable by one valve at the end of Jaun Bazar to Wellesley Street.

**No. 19 Loop, South-West.**—A 6-inch pipe from Wellesley Street along Joratalao Street, 4-inch in part of Free School Street, Sudder Street, Kyd Street and Chowringhee Road, closeable by one valve at Wellesley Street.

**No. 20 Loop, South-West.**—A 2-inch pipe in South Collingah Street, from Wellesley Street through part of Free School Street, returning by Royd Street to Wellesley Street, closeable by two valves at Collingah and Royd Streets, in Wellesley Street.

**No. 21 Loop, South-West.**—A 3-inch pipe from Park Street, along Middleton Row and Camac Street, to Park Street, closeable by two valves in Park Street.

**No. 22 Loop, South-West.**—A 6-inch pipe along Chowringhee Road, from Park Street, to Middleton Street, 4-inch along Middleton and Russell Streets, back to Park Street closeable by two valves in Park Street.

**No. 23 Loop, South-West.**—A 6-inch pipe from Wood Street through Short's Bazar Street to Camac Street, 4-inch along Camac Street through part of Middleton Street, Little Russell Street, Chowringhee Road to Harrington Street and Theatre Road, closeable by two valves, one in Wood Street and one at the end of Theatre Road, Chowringhee.

**No. 24 Loop, South.**—A 6-inch pipe from Theatre Road, along Chowringhee Road and Circular Road to Elysium Row, 4-inch from Elysium Row to Theatre Road, closeable by two valves at Theatre Road, Chowringhee and Elysium Row.

**No. 25 Loop, South.**—A 6-inch pipe along Dalhousie Street, Victoria Square to Camac Street, and Circular Road, remainder of Victoria Square, all 3-inch, closeable by one valve at Dalhousie Street, Theatre Road.

**No. 26 Loop, West.**—A 6-inch pipe along the Strand Road, from Esplanade Row to Fort Point, with one valve.

127. Care to be taken that branches be left at the side streets in each loop or district which are not at present specified for further extensions, but on no account are too loops to be coupled together.

Any extension of the pipes which may become necessary will be strictly confined to one or other of the districts above described, and should be so put in as to avoid, as far as practicable, all "dead ends." In other words, on opening the valves connecting the Trunk with the District Mains, the water should circulate freely through all the pipes of that district, and that, as far as practicable, both ends of any pipe inserted should be extended so as to connect with pipes in the same district.

128. LENGTH OF MAIN PIPES IN YARDS.

Low Pressure Division.

NAME OF STREET.	Number of Valves.	30 Inch.	24 Inch.	18 Inch.	12 Inch.	9 Inch.	DIAMETER.
TRUNK MAINS.							
Tallah Works to Circular Road Junction	1	1,408					
Thence to Wellington Square ..	4	...	4,864				
Sham Bazar Street ..	2	...	...	1,344			
Nimtollah Street ..	1	...	...	...	780		
Upper Chitpore Road to Muchooa Bazar Street ..	2	...	...	...	2,200		
Total ..	10	1,408	4,864	1,344	2,980		

129. HIGH PRESSURE DIVISION.

Wellington Street ..	1	...	220	...	740		
Boitakhannah Street ..	1	...	...	...	1,110		
Wellesley Street ..	2	...	...	1,620			
Dhurrumtollah Street ..	4	...	...	1,790			
Circular Road to Sealdah ..	...	...	...	...	800		
Esplanade Row through Government House Compoural ..	...	...	...	430	660		
Old Court House Street ..	1	...	...	...	890		
Tank Square, North ..	1	...	...	...	300		
Clive Street to Clive Ghât ..	...	...	...	...	430		
Lall Bazar ..	1	...	...	...	265		
Lower Chitpore Road ..	...	...	...	...	1,110		
Wood Street ..	1	...	...	...	680		
Trunk Mains.							
Park Street, E. and W. ..	2	...	...	...	1,620		
Theatre Road, E. and W. ...	...	...	...	...	...	1,465	
Southern Division ..	14	...	220	3,840	8,585	1,465	
Northern ditto ..	10	1,408	4,864	1,344	2,980		
Total	24	1,408	5,084	5,184	11,565	1,465	Yards.

Sizes of Valves,	30	24	18	12 Inch.
Number required,	1	4	8	11

## LOW PRESSURE DIVISION.

LOOP OR DISTRICT PIPES. PARTICULARS AND LENGTHS IN YARDS.

Number of Loop.	Name of Street.	Number of Valves.	9 Inch.	6 Inch.	4 Inch.	3 Inch.	Diameter.
No. 1, West.	Sabah Bazar Street .. } Hatcolgh ... .. }	2	...	660 812			
No. 2, West.	Puttoreah Ghât Street .. } Strand Road, part of .. } Durmahatta Street, part of .. } Nawab Ghât Street ... }	2	...	640 872 896	148		
No. 3, West.	Rutton Sircar's Garden Street } Durmahatta Street, part of .. } Banstollah Street .. } Burtollah Street .. } Cotton Street ... }	2	...	...	730 336 ...	740 586	
No. 4, Centre.	Bang Bazar Street .. } Upper Chitpore Road to Sabah } Bazar Street ... }	2	...	1,100 808			
No. 5, Centre	Rajah Nobkissen Street ..	2	...	1,030			
No. 6.	Rajah Gooroodoss' Street, a line } drawn through to .. } Hindoo College .. } Manicktollah and Branches .. }	2	...	1,010	1,261		
No. 7, Centre.	Baranossy Ghose's Street ..	2	...	...	1,115		
No. 8, Centre.	Mooktaram Baboo Street ..	2	...	...	954		
No. 9, Centre.	Muchooa Bazar Street, part of } Halliday Street .. } Colootollah Street .. }	3	...	890 586 840			
No. 10, East.	Upper Circular Road ..						
No. 11, East.	From Cornwallis Street to Kur- } bullah Tank .. } Circular Road, part of .. } Manicktollah Street, part of .. } Cornwallis Square, part of .. }	1	810	300 750	220		
No. 12, East.	Sooke's Street .. } Amherst Street, part of .. } Muchoa Bazar Street, part of } Circular Road, part of .. }	2	...	880 532 1,022 660			
No. 13, East.	Mirzapore Street .. } Amherst Street, and by way of } North Gowconnah .. } Circular Road, part of .. }	2	1,020	...	590	586	
Total, Low Pressure Division ..		24	1,830	14,908	5,414	1,912	



## HIGH PRESSURE DIVISION.

LOOP OR DISTRICT PIPES. PARTICULARS AND LENGTHS IN YARDS.

Number of Loop.	Name of Streets.	Number of Valves.	9 Inch.	6 Inch.	4 Inch.	3 Inch.	Diameter.
No. 1, West.	Armenian Street ...	2	...	660	...	142	
	China Bazar Street, part of ...		...	...	480		
	Kengra Puttee Street ...		...	...	140		
	Kamul Nyn, ke Ber' ...		...	...	...		
	Cross Street ...		...	...	456		
	Moorgehatta Street ...		...	730	...		
	Strand Road, part of ...		...	592	...		
	Clive Street, part of ...	1	...	...	605	513	
	Jackson's Ghât Street ...		...	110	...		
No. 2, West.	Rada Bazar Street ...		...	430	...		
	Old China Bazar, part ...		...	75	...		
	Doomtollah Street ...		...	...	336		
	Pollock Street, part of ...		...	...	...		
	New China Bazar ...		...	...	256		
	Lyons' Range, part of ...	2	...	...	248	108	
	Swallow Lane ...		...	...	...		
No. 3, West.	Fairlie Place ...	2	...	520	108		
	Strand Road, part of ...		...	...	...		
	Clive Ghât Street ...	2	...	...	880		
No. 4, West.	Tank Square, North ...		...	...	...		
	" " West ...		...	...	...		
	" " South ...		...	...	...		
	Council House Street ...		...	...	730		
	Government Place, North, part ...		...	...	...		
	Wellesley Place ...		...	...	...		
No. 5, West.	Government Place, West ...	3	...	220	...		
	Hastings' Street ...		...	404	...		
	Church Lane ...		...	...	...		
	Hare Street, part of ...		...	...	294		
	Bankshall Street ...		...	...	...		
	Coilah Ghât Street, part of ...		...	...	615		
	Old Post Office Street ...		...	...	...		
No. 6, Centre.	Strand Road, part of ...	2	...	730	220		
	Bow Bazar, from ...		...	880	...		
No. 7, Centre.	College Street to Cossitollah ...	1	...	...	...	105	
	Cossitollah Street ...		...	...	...		
	Lall Bazar, Duplicate ...		...	945	...		
	Mission Row ...		...	...	220		
	Mangoe Lane, part ...		...	...	280		
	Raneemoody Gully } Loop ...		...	...	310		
	& Waterloo Street ...		...	...	...		
No. 8, Centre.	Old Court House Street, part ...	1	...	...	190	265	{ G. E. Hotel Supply.
	Raneemoody Gully ...		...	...	265		
	Waterloo Street ...		...	...	...		
	Dacre's Lane, part of, and ...		...	...	...		
	Crooked Lane ...	1	...	...	...	184	
No. 9, Centre.	Emambaug Lane ...		...	...	880		
	Weston's Lane ...		...	...	...		
	Emambara Lane and ...		...	...	...		
	Part of Cossitollah ...		...	...	...		
	Chandnee Choke ...		...	...	330		
	Dharrumtollah, part of ...		...	...	...		
	Hospital Lane ...	1	...	...	430	722	
No. 10, East.	St. James' Street ...		...	730	...		
	Wellington Square, part of ...		...	...	...		
	Creek Row and other Lanes ...	2	...	...	750		
No. 11, East.	Lall Bazar Street, East ...		...	956	...		
No. 12, East.	Wellesley Square, part of ...	2	...	...	1,180		
	Kalla Chand Lane ...		...	...	...		
	European Asylum Lane ...		...	...	...		

No. of Loop.	Name of Streets.	Number of Valves.	9 Inch.	6 Inch.	4 Inch.	3 Inch.	Diameter.
No. 13, East.	Circular Road from Dhurum-tollah to Park Street and Theatre Road ...	6	2,214				
No. 14, East.	South Collingah Street, East ...	2	...	...	...	880	
No. 15, East.	Elliott's Road and Royd Street...	2	...	...	874		
No. 16, East.	Loudon Street, part of ...		...	447			
	Rawdon Street, part of ...		...	...	170		
	Short's Bazar Street, part of...		...	...	513		
	Robinson Street ...	1	...	...	...	220	
	Outram Street ...		...	...	...	330	
	Hungerford Street and part of Theatre Road ...		...	...	...	562	
No. 17, East.	Loudon Street, part of ...		...	435			
	Circular Road, part of ...		...	1,027			
	Hungerford Street, part of ...	2	...	...	293		
	Moir Street ...		...	...	...	420	
	Auckland Square ...		...	...	...	465	
	Rawdon Street ...		...	...	...		
No. 18, South-West.	Jaun Bazar, part ...		...	840			
	Chowringhee Road, part ...		...	430			
	Lyndsay Street ...	1	...	...	440		
	Free School Street, part ...		...	...	370		
	Jaun Bazar Lanes ...		...	...	...	580	
No. 19, South-West.	Joratallao Street ...		...	206			
	Free School Street, part ...		...	...	285		
	Kyd Street ...	2	...	...	470		
	Sudder Street ...		...	...	470		
	Chowringhee Road, part ...		...	...	410		
No. 20, South-West.	South Collingah Street, part...		...	...	...	920	
	Free School Street, part ...	2	...	...	...		
	Royd Street, part ...		...	...	...		
No. 21, South-West.	Middleton Row and Camao Street, part of ...	2	...	...	...	520	
No. 22.	Chowringhee Road, part ...		...	660			
	Middleton Street, part ...	2	...	...	142		
	Russell Street ...		...	...	586		
No. 23, South-West.	Short's Bazar Street, part ...		...	110			
	Camac Street, part ...		...	...	220		
	Middleton Street, part ...		...	...	528		
	Little Russell Street, part ...	2	...	...	230		
	Chowringhee Road ...		...	476			
	Harrington Street ...		...	...	524		
No. 24, South.	Chowringhee Road, part ...		...	476			
	Circular Road, part ...	2	...	145			
	Elysium Row ...		...	...	528		
No. 25, South.	Dalhousie Street ...		...	224			
	Camac Street, part ...		...	330			
	Victoria Square ...	1	...	...	...	874	
	Chowringhee Road, part ...		...	124			
No. 26, West.	Strand Road from Chandpal to Fort Point ...	1	...	1,500			
	Total ...	48	2,214	15,202	17,214	2,356	

## MAIN PIPES.

## GENERAL SUMMARY.

## Low Pressure Division.

Trunk Main	...	30-inch,	1,408 yards, or	470 Pipes.
		24 "	4,864 "	1,622, 9 feet each.
		18 "	1,844 "	448 "
		12 "	2,980 "	994 "
Loop Mains	...	9 "	1,830 "	610 "
		6 "	14,908 "	4,969 "
		4 "	5,414 "	1,805 "
		3 "	1,912 "	638 "
Total			34,660 yards.	

## High Pressure Division.

Trunk Mains	...	24-inch,	220 yards, or	74 Pipes.
		18 "	3,840 "	1,280 "
		12 "	8,585 "	2,862 "
		9 "	1,465 "	489 "
Loop Mains	...	9 "	2,214 "	738 "
		6 "	15,202 "	5,068 "
		4 "	17,212 "	5,738 "
		3 "	8,336 "	2,779 "
Total			57,074 yards.	

## Weights.

		Cwt.	Qrs.	lbs.		
470	30-inch,	25	2	0	each, or Tons	599 5 0
1,696	24 "	18	0	0	"	1,526 8 0
1,728	18 "	12	2	0	"	1,080 0 0
3,856	12 "	6	2	0	"	1,253 4 0
1,837	9 "	4	2	0	"	413 6 2
10,037	6 "	2	2	14	"	1,317 7 0
7,543	4 "	1	2	14	"	612 17 1
2,417	3 "	1	0	21	"	202 6 3
Total Tons						7,004 14 2

133 The total length of pipes in Low Pressure Division is 34,660 Yards,  
High Pressure ... 57,074 "

Total ... 91,734 Yards,

or rather more than 52 miles

134. The position of the pipes, &c., in the above arrangement is shewn on the small Plan of Calcutta, Drawing No. 17. Additional pipes can be inserted into any one of the 'loops' or districts shewn on the Plan, as the more extended distribution of the water becomes necessary, and it is to be borne in mind that the pipes included in this arrangement are fully equal to the distribution of twelve million gallons per day.

135. The estimate for the entire machinery and works at Pulta	...	}	
Aqueduct to Tallah	...		
Engines and Reservoirs, &c., at Tallah	...		£ 848,774 0 0
Engines and Reservoirs at Wellington Square	...		
Magneto-motive for Filter at Pulta	...		29,064 0 0
Price and cost of lands to be taken for the works	...		11,082 0 0
			<u>£888,920 0 0</u>

The cost of Trunk and District Mains with Valves, Hydrants, &c., &c., for distribution according to the foregoing scheme...	£ 110,320	0	0	
Deduct Pipes, Valves, Hydrants, &c., received from England and in part laid for Nimtollah supply	3,644	0	0	106,676 0 0
				£ 495,596 0 0
Engineering and Contingencies, 10 per cent., say	.....			75,000 0 0
Total	...			£ 570,596 0 0

136. BARRACKPORE SUPPLY.

The cost of works for supply of Barrackpore with 120,000 gallons per day, including an elevated tank 50 feet high, and 4,660 yards of 9" Main Pipe, is ... £ 6,500 0 0

137. SUPPLY FOR DUM-DUM.

60,000 Gallons per day.

The cost of 6,600 yards of 6" Pipe with Valves, &c. (an elevated tank will not be required as the engines will work constantly with a pressure of 50 feet)... £ 4,600 0 0

138. AFTER COMPLETION.

The current working expenses are estimated as follows:—

	Rs. per mensem.	Rs. per annum.	Total per annum.
Pulta Works	3 510 0 0	42,120 0 0	
Tallah Works	3,877 0 0	46,524 0 0	
Calcutta Pumping Station	4,100 0 0	49,200 0 0	
Depreciation and repair of Works	.....	.....	1,37,844 0 0
			2,00,000 0 0

ESTABLISHMENT.

	Rs. per mensem.	Rs. per annum.	
Chief Engineer	1,000 0 0	12,000 0 0	
Assistant Engineer	600 0 0	7,200 0 0	
1 Head Writer and Accountant	200 0 0		
4 Native Writers	100 0 0		
6 Turn-Cocks	600 0 0		
Punkah-pullers, &c.	100 0 0		
	1,000 0 0	12,000 0 0	31,200 0 0
		Total Rs. ...	1,89,044 0 0

139. If to the annual working expenses ten per cent. on the cost of the works be added for re-payment of the loan raised for their construction ... 5,70,596 0 0

Total, Rs. ... 7,59,640 0 0

The total cost of the water as delivered, half at 50, and half at 100 feet pressure in Calcutta, six million gallons per day, will be about one Rupee per 3,000 gallons.

140. It is intended to keep the Pipes constantly full and under pressure so as to render pistons unnecessary.

The minor arrangement for distribution will form the subject for future report.

141. For special purposes a supply by meter offers some advantages, and not the least in importance in this city would be the employment of water as motive power for pulling punkahs.

There are several forms of water meter which could be adapted to the purpose. One such of Mr. Duncan, of the Liverpool Water-works, has been procured. These little machines would record the quantity of water passing through them when employed to pull the punkah, and they could afterwards be discharged into a cistern in the compound and used for domestic purposes, washing carriages, &c.



*Draft Declaration under Act VI. of 1857.*

WHEREAS it appears to the Hon'ble the Lieutenant-Governor of Bengal that land is required to be taken by Government, at a public expense, for a public purpose, viz. for the Calcutta Water-works; It is hereby declared that, for the above purpose, a plot of land measuring seventeen beegahs ten cottahs, more or less, the property of Radhamadhub Boral and others, situated in Mouzah Tallah, and recorded as holding No. 73, Sub-Division XVIII, Grand Division I., of Khass Mehal Dhee Punnchannogram, is required.

It is bounded on the North by holding No. 72, the property of Buro Modoo Soodun Chatterjee; on the South by a public lane and holdings Nos. 74, 75, and 77, the properties of Bassandy Dossee, Buro Modoo Soodun Chatterjee, and Ram Doolaul Sircar, respectively; on the East by holdings Nos. 67 and 70-1, the properties of Denoobundo Paul and Rajah Jadub Kisto Bahadur; and on the West by the Barrackpore Road.

This Declaration is made, under the provisions of Act VI. of 1857, to all whom it may concern.

*Draft Declaration under Act VI. of 1857.*

WHEREAS it appears to the Hon'ble the Lieutenant-Governor of Bengal that land is required to be taken by Government, at a public expense, for a public purpose, viz. for the Calcutta Water-works; It is hereby declared that, for the above purpose, a piece of land in Mouzah Moneerampore, Pergunna Calcutta, District 24-Pergunnahs, measuring 450 beegahs, more or less, is required.

It is bounded on the North and West by the River Hooghly; on the South by the River Alluvial and Deyparali Road; and on the East by the Kurbulla Ghat and Dheetarah Road. Also a strip of land about 1,400 feet in length and 20 feet in width running through gardens along the north of the Dheetarah Road and connecting the land defined above with the Cantonment Road.

This Declaration is made, under the provisions of Act VI. of 1857, to all whom it may concern.

*Draft Declaration under Act VI. of 1857.*

WHEREAS it appears to the Hon'ble the Lieutenant-Governor of Bengal that land is required to be taken by Government, at a public expense, for a public purpose, viz. for the Calcutta Water-works; It is hereby declared that, for the above purpose, a strip of land 70 feet long and 20 feet in width running southward from the turn of the road from Barrackpore to Calcutta precisely at the south-eastern corner of the Government Park and re-joining the said road at a distance of 700 feet, measuring about one beegah, more or less, is required.

This Declaration is made, under the provisions of Act VI. of 1857, to all whom it may concern.

*Draft Declaration under Act VI. of 1857.*

WHEREAS it appears to the Hon'ble the Lieutenant-Governor of Bengal that land is required to be taken by Government, at a public expense, for a public purpose, viz. for the Calcutta Water-works; It is hereby declared that, for the above purpose, a plot of land measuring three beegahs eighteen cottahs and nine chittaks, more or less, is required.

It is bounded on the North by Mullunga Lane; on the South by a blind lane; on the East by Wellington Street, and on the West by Bepary-tallah Lane, and comprises holdings Nos. 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35 of block No. 13,

South Division, being, respectively, the properties of Mr. W. J. Bampton, Amanut jummah-Commissioners for the improvement of the Town of Calcutta, Sonamoney Dossee, Boddinath Dhan; Sokeesoondory Dossee, Bholanath and Bissonath Kurmukur, Rajkisto Mitter, and Prawnkisto Surnokar.

This Declaration is made, under the provisions of Act VI. of 1857, to all whom it may concern.

*Draft Declaration under Section II. of Act VI. of 1857.*

WHEREAS it appears to the Hon'ble the Lieutenant-Governor of Bengal that land is required to be taken by Government, at a public expense, for a public purpose; It is hereby declared that, for the above purpose, a strip of land running from the Main Road through the Bazar along the eastern boundary of the Barrackpore Cantonment, touching the eastern corner of the Officers' residences at a length of 2,000 feet and width of 20 feet and measuring about two beegahs, more or less, is required.

This Declaration is made, under the provisions of Act VI. of 1857, to all whom it may concern.

*List of Plans.*

*Drawing No. 1.*—Shewing plan of arrangement of engines, settling tanks, filters, &c., at Pulta.

*Drawing No. 2.*—Section of aqueduct from Tallah to Pulta.

*Drawing No. 3.*—Plan of screw pile jetty for Pulta.

*Drawing No. 4.*—Plan of settling tank shewing arrangement for admission of river water, exit of clear water, and for cleansing.

*Drawing No. 5.*—Details of settling tanks.

*Drawing No. 6.*—Part plan of filter.

*Drawing No. 6 A.*—Details of filters.

*Drawing No. 7.*—Plan and Section of aqueduct through Barrackpore Cantonment.

*Drawing No. 8.*—Shewing section of, Barrackpore Road and aqueduct.

*Drawing No. 8 A.*—Culvert at 4,129 feet north of eleventh mile-stone, Barrackpore Road.

*Drawing No. 9.*—Aqueduct, from Pulta to Tallah.

*Drawing No. 10.*—Plan of covered reservoir for Wellington Square.

*No. 11 Plan of Calcutta.*—Shewing arrangement of water main pipes.

*Drawing No. 12.*—Details of saddle for the crossing Chitpore Canal.

*Map of Calcutta.*—Shewing latest improvements as existing in 1854.

It appears to me that the Town is well able to pay the annual cost of its supply of water, say,—

Interest on 50 lacs	Rs. 3,00,000
Working expenses and petty repairs	2,00,000
Depreciation at 2 per cent.	1,00,000

Total Rs. 6,00,000

say this is raised partly by water-rate and partly by payment for water used.

The water-rate should cover all water used for the streets and for water supplied to the street stand-pipes and public tanks.

Fix the water-rate at 1 per cent. on the house valuation, allowing 2,000,000 gallons daily, say 680,000 gallons for watering twice all the streets in which pipes are laid, leaving 1,320,000 gallons

for general consumption, or at four gallons per head for the poorer classes, sufficient for 830,000, or three-fourths of the population.

The water-rate would yield say Rupees 2,00,000, leaving 4,00,000 gallons for distribution on payment at a charge which must return Rupees 5,00,000 per annum, that is

$$\frac{4,00,000 \times 865}{500,000} = \text{No of gallons per Rupee}$$

$= 10 \times 73 = 2,920$ , or say 3,000 gallons per Rupee. One mussuck contains fifteen gallons, therefore a quantity  $= 200$  mussucks, would be obtained for one Rupee of pure water, whereas at present one pie is charged per mussuck, when the water can be procured at no great a distance, or only sixty-four mussucks of impure water for the Rupee, and in the hot season the charge is higher.

The next question then will be, would there be enough consumers to pay this very low charge?

Allow thirty gallons for each consumer per day,

N. B.—Thirty gallons per head is said to be a good average allowance for a town, but the poorer classes do not consume more than from four to six gallons per head, so that the actual consumption of the higher classes must be more than thirty gallons per head.

and the number of consumers required would be 134,000 or about one-fourth of the entire population, exclusive of the Shipping.

Considering that Hospitals, Markets, Schools, and Public Institutions would certainly take a much larger quantity, and considering also that the Shipping would be large-paying consumers, there can be little doubt that this sum would be obtained and that the town would afford to pay for its Water-supply without difficulty.

V. H. SCHALCH.

From DABOO JOTENDRO MOHUN TAGORE, Honorary Secretary, British Indian Association, to the HON'BLE A. EDEN, Secretary to the Government of Bengal,—(dated the 23rd February 1865.)

The Committee of the British Indian Association observe that the Justices of the Peace for Calcutta adopted, at their ordinary Meeting of the 6th instant, a scheme of Water-supply for the town prepared by their Engineer, the cost of which has been estimated at £570,596, or in round sum Rupees sixty lacs. The Justices resolved to raise this sum by loan to provide for the payment of interest on such loan pending the completion of the works by reserving ten lacs from the present Water-supply funds expected to amount to fifteen lacs after the grant from the Income Tax proceeds for the current year, and to apply to the Legislature for the amendment of Section LXI. of Act VI. of 1863, so as to render it compulsory on the Justices to enforce, at the completion of the works, such an annual water-rate as shall cover the payment of interest on the Water-supply loan, the current expenses, maintenance and depreciation of the works, less such sum as may be obtained by sale of the water.

It is admitted on all hands that one of the most pressing and essential works devolving on the Municipality is to provide for the supply of good and wholesome drinking water to the inhabitants of the Town, the want of which has long been felt and repeatedly urged on the attention of the Municipal Commissioners. The Committee, therefore, notice with great satisfaction that a scheme has at last been prepared to remove this crying want of the Town.

The Committee do not pretend to discuss the engineering merits of the scheme; it may be as perfect as, the Public are assured by the Justices, any scheme can be; but they cannot forbear expressing their regret that in maturing this scheme neither the Engineer nor the Justices seem to have duly borne in mind the financial position of the Municipality. They do not for a moment dispute the desirableness of obtaining Municipal improvements for Calcutta of the most perfect and elaborate description in a most magnificent and imposing style and meeting all the conveniences of the citizens; but it is important to consider whether all such improvements can be effected with the ordinary and well-ascertained resources of the Municipality, even when carried to the highest practicable state of development, or whether their adoption would place it in absolute bankruptcy.

The total income of the Municipality during the past year amounted to Rupees 12,51,934, or, adding thereto the balance of the previous year and extraordinary and special receipts, to Rupees 14,45,360, while the total expenditure was Rupees 13,20,315, leaving a balance of Rupees 1,25,045, part of which again would be required to meet the demands of the past year. When it is remembered that the Municipality is in the first stage of constitutional organization; that the primary requirements of the Town, whether in respect of drainage, conservancy, or road improvements, have not been supplied, and that its wants must increase with the increase of time, and its charges swell with the rise in the wages of labour and prices of materials, the income indicated above, even taking into account its probable augmentation owing to increased value of landed property hereafter, will scarcely be sufficient for all purposes of expenditure.

If it were contended that the completion of the Drainage works, the prospect of which was by no means near, would diminish the conservancy expenditure, such diminution would scarcely contribute to the material relief of the Municipal Funds. The allotment in the Municipal Budget for 1865 for the sewerage and other conservancy charges is Rupees 3,25,000, and, considering this amount to be the normal expenditure for conservancy much of this sum would, the Committee fear, have still to be provided for even after the completion of the drainage works. The Drainage scheme cannot, if the Committee are not misinformed, be extended to all parts of the town owing to the smallness of the streets and other difficulties, and there dry conservancy must be employed, while the expenses for removing the offal of the town must be incurred as heretofore. It is, however, not improbable to suppose that the saving which may be effected by the operation of the Drainage scheme may, in a great measure, be absorbed by the working expenses and depreciation of works consequent on the new system, not to say that the other requirements of the town will remain in full force if they will not increase in number and magnitude and must be met from the ordinary ways and means of the Municipality.

On the other hand, it cannot be denied that the taxation of the town has already been carried to the highest practicable limit, and that further augmentation of it would press on the rate-payers with a severity which their circumstances generally would not warrant, nor would it be good policy to impose. The income of the Municipality

since the introduction of the new system, and the imposition of the new rates and taxes, has nearly doubled, and we need hardly add that the burden on the rate-payers has increased in the same proportion.

Such being the present position and future prospects of the revenues of the Municipality, it is of paramount importance to consider whether the proposed scheme of Water-supply is feasible in a financial point of view. The total cost of the works, it is estimated, will amount in round sum to sixty lacs, assuming, though it is not safe to do so, that the actual expenses will not exceed the estimate, while the annual working charges will, it is stated, come to Rupees 1,89,044, or making allowance for contingencies to about two lacs, which, with the interest on sixty lacs at the rate of 6 per cent. per annum calculated at Rupees 3,60,000, will make an annual charge of Rupees 5,60,000 upon the Municipal Funds on account of Water-supply alone.

To meet this enormous annual charge the Justices have only two means at their disposal authorized by law, *viz.* to levy a general water-rate of 2 per cent. per annum upon all houses, buildings, and lands in the Town, and to sell water to private individuals at a graduated scale of rates. The produce of the first mentioned rate may be calculated at Rupees 1,75,000, considering that the entire proceeds of the house-rate at 10 per cent. did not yield last year more than Rupees 8,54,515,—a sum which would not cover wholly the annual working expenses of the scheme under notice. What may be the yield by sale of water the Committee, in the absence of any specific data, are unable to estimate, though they feel persuaded that it will not come to a large figure. In the first place, the prospect of an extensive sale of water in the Northern Division must be very remote in the presence of deep-rooted prejudices which exist among orthodox Hindus, not to say that the circumstances of the bulk of the Native inhabitants of the town will scarcely permit them to pay for the luxury of obtaining water at high pressure. In the second place, although the European inhabitants will readily appreciate the advantages of the supply of water at high pressure, the Committee are still not without doubt whether middle class Europeans, by far the most numerous in the town, to whom the present costliness of living is a matter of serious concern, will be equally willing to bear a double tax for the sake of obtaining water at high pressure when they will obtain equally good water at low pressure without any addition to the general water-rate. But whatever may be the yield by sale of water, it is sure to leave a large deficit on Water-supply account, which cannot be met without resorting to fresh and heavy taxation. So far as the Committee now perceive, a water tax of more than 7 per cent. will be necessary to provide for an annual charge of nearly six lacs, not to say that no means will be left to re-pay the loan hereafter.

It needs be added that the above calculation has been made on an assumption that the actual cost will not exceed the estimated amount; but the Committee, with due humility, confess that they are reluctant to repose faith in the estimates of the Calcutta Municipality. The original estimate for carrying out the drainage scheme, it may be remembered, was given at the comparatively moderate sum of Rupees 32,85,000 after the same

being tested by competent and eminent engineers; but the actual cost, it is now believed, will exceed a crore, if not a crore and a half, though it is feared that the benefit of improved drainage cannot be extended to all parts of the town. As regards the estimates of Water-supply they have been increasing in amount in such proportion, compared to the increased income of the Municipality, as to place the realization of the scheme successively beyond its reach. First the Drainage Committee estimated the cost at Rupees 11,55,000, to meet which the Municipality has now more than enough funds in hand; then the present Corporation estimated it at forty lacs, and now they estimate it at sixty lacs. Be that as it may, the Committee have grave doubts whether the actual cost will not exceed the estimated amount. If such should prove ultimately to be the case, as the Committee believe it will, the proceeds of a heavy water-rate of even 7 per cent. would not meet the total requirement.

The Committee have not adverted to other loans which the Justices propose to contract for purposes of drainage works and city improvements. What the actual cost of these works and improvements will eventually come to it is impossible to say; but if the whole permanent debt of the town, on all accounts, should reach two crores, by no means an improbable inference, the whole of the present income of the Municipality will stand pledged for interest on that debt at the rate of 6 per cent. per annum. Such a state of things, the Committee need hardly add, is deeply to be regretted.

It remains for His Honor the Lieutenant-Governor to consider whether he should seal with his sanction a financial policy of such a dangerous tendency; whether he should allow the Municipal Corporation to impose such an unfair and unwarrantable obligation on posterity, and whether he should consent to the crippling of the resources of the Municipality to a degree rendering it almost impossible for the successors of the present Commissioners to undertake the responsibility of administering its affairs.

The Committee have observed above that the supply of good drinking water has long been a crying want of the town. Nor are they unaware that a copious and diffused Water-supply is considered essential to the efficient working of the Drainage scheme. But the question is whether this two-fold object cannot be met by a scheme consistent with the means of the Municipality. The town cannot afford for that elaborateness which the Engineer has designed. All that the inhabitants want is wholesome water for drink, and it was the duty of the Municipality to consider whether it could not be supplied at a moderate expense. This question was discussed by the Drainage Committee appointed in 1856, who put the issue in the following pertinent form:—

“Whether by a system complete in itself and supplying filtered water to all parts of the city at high pressure, or whether, considering the habits and prejudices of the people, and the systems adopted in Continental Europe, where more is drawn from public fountains than in English towns, it will be sufficient to extend the system which is now in operation and supply water to tanks and fountains in the different parts of the city by several engines of smaller power situated at different and favorable points along the bank of the river, or by one large engine.”



The Drainage Committee had two schemes before them, viz. one prepared by Mr. Simms, Consulting Engineer to Government in February, 1847, and another, a modification of Mr. Simms', designed by Hawkesley, Civil Engineer, and Captain C. B. Young, of the Engineers, in February 1852. The estimate of the scheme of Mr. Simms, who, like Mr. Clark, proposed to pump up water at Pulta, was sixty-seven lacs, and based on sound principles, and elaborate as it was the Drainage Committee rejected it on the ground of its expensiveness. The same considerations which led the Drainage Committee to negative the otherwise admirable scheme of Mr. Simms apply with equal force to the present analogous scheme of Mr. Clark. The estimate of the scheme of Mr. Hawkesley and Captain C. B. Young, who also proposed to obtain water at Pulta, was sixteen lacs, but the Drainage Committee reduced the estimate to Rupees 1,55,000 by making further modifications in order to bring the cost within the means of the Municipality.

The necessity of a cheap system of Water-supply for Calcutta is now as great as it was before. But this point, it seems, was not sufficiently considered by the Justices. On the contrary the motion for the adoption of the Report of the Engineer with the recommendations of the Water-supply and Finance Committees was carried with such hot haste at the Meeting of the 6th February, notwithstanding a proposition for adjournment duly moved and seconded, that the Committee are not without doubt whether this vitally important question received that attentive consideration from the body of the Justices which it so eminently deserved.

In the humble judgment of the Committee the proposal of the Drainage Committee, the principle of which they believe is recognized in the Continental systems, to "supply water to tanks and fountains in the different parts of the city by several engines of smaller power situated at different and favorable points along the bank of the river or by one large engine," is entitled to great weight. By rendering this process auxiliary to the Drainage scheme, as the Drainage Committee proposed to do, and supplementing it with a system of tanks, the requirement of the town, the Committee venture to think, may be met without subjecting it to heavy taxation. The original estimate of the Drainage Committee for Water-supply may be made the basis, with such additions as may be required by further modifications as well as by the present increase in the price of labour and materials. The Water-supply Funds, amounting to fifteen lacs, will doubtless go a great way to meet the expenditure.

A system of tanks will be attended with a double advantage. It will lead to the opening of large squares, securing free ventilation of air, and thus promoting the general salubrity of the town. The Northern Division, which, by reason of its overcrowdedness and small streets, is closed against the accession of fresh air, and which, within its whole area, has only two squares, will greatly benefit by the proposed system. The squares and tanks will, on the other hand, pay not a little of the expenses likely to be incurred by the sale of surplus land, while the increase which will necessarily be effected in the value of lands and houses in their vicinity will indirectly contribute to swell the proceeds of the House Tax. The

Committee do not believe it is contemplated by the Justices to form the opening of tanks and squares a part of the scheme of Water-supply under notice, and if these improvements are to be carried out in addition to the proposed water-works, they must involve an additional outlay.

The tanks may be filled with river water in the months of December, January, and February, so as to give a full supply for the succeeding three or four months when the water is less fit for drink, while rain water may be stored in them from July to October. If necessary, and if the funds of the Municipality will allow, some of the tanks may be converted into filtering reservoirs.

The Committee do not believe objection will be taken to the system on the ground of the supply being limited to tanks and fountains when tanks are being opened on the Maidan for the purpose of supplying the population in the Fort with drinking water. It is true that water will be supplied to the Fort at high pressure, but if those who want to enjoy the luxury will not grumble to pay for it, it will by no means be difficult for the Municipality to make the necessary arrangements, as has been done in the case of Gas light. What the Committee wish and hope to see practically recognized by the Justices is that the whole community may not be burdened with a tax for the convenience of a few.

It is superfluous for the Committee to observe that the prohibition of the practice of throwing dead bodies into the Hooghly, coupled with the cessation of discharging night-soil into it, contemplated by the Justices, is calculated greatly to purify the river-water, and when it will settle in tanks it will doubtless be more fit for drink than now.

The Committee are glad to notice that such distinguished scientific men as Drs. Chevers and Macnamara advocate a system of tanks for supplying Calcutta with drinking water. Dr. Macnamara was requested by the Municipal Commissioners in 1863 to report on the water of the Hooghly, and after a patient and careful examination and analysis pronounced the Maidan tank water superior to the river water. After stating his opinion on the water of the several Maidan tanks Dr. Macnamara remarks—

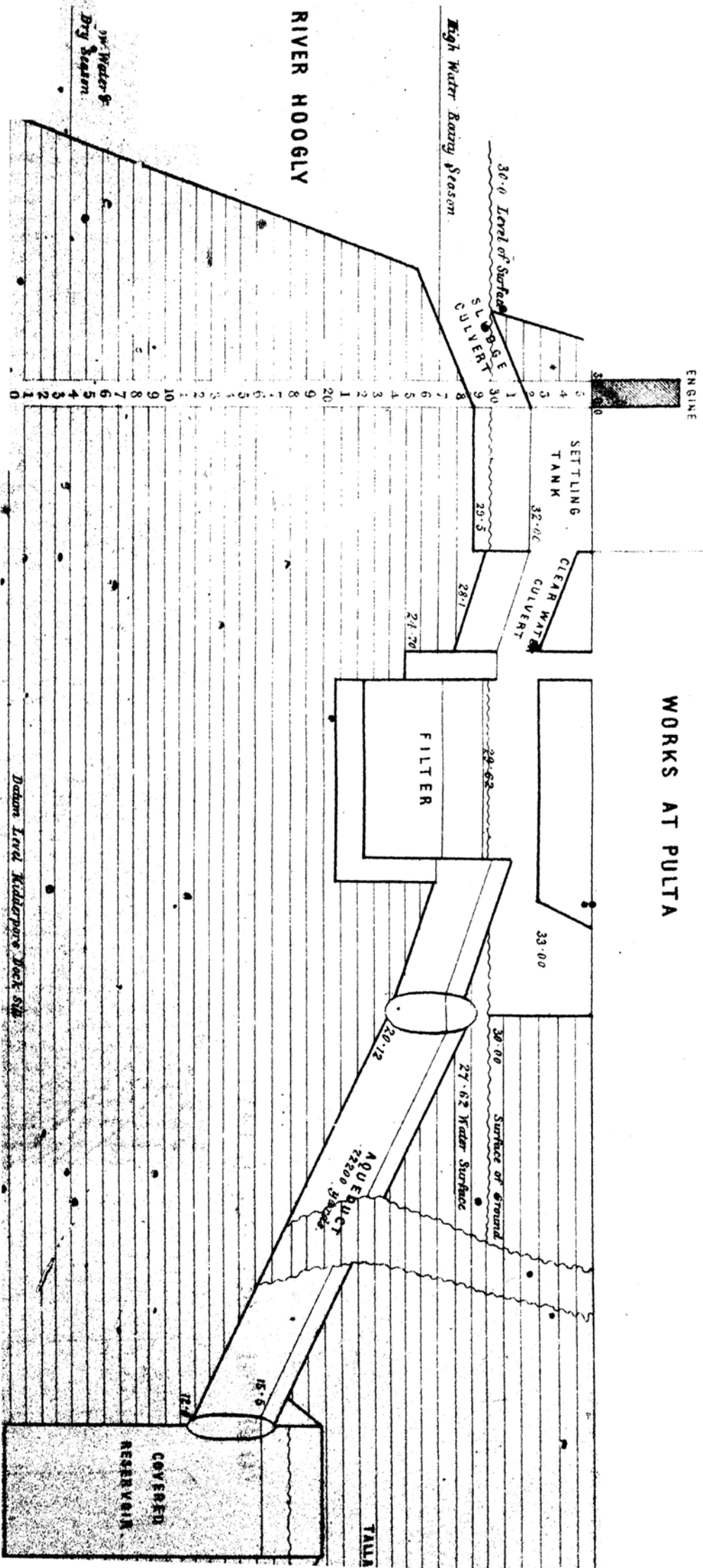
"Dr. Chevers has proposed that the Maidan should be used as a gathering ground for the Water-supply of Calcutta. He is, I believe, confident that the supply would be ample, and as there can be no question as to the superiority of the Maidan tank water to that of the river, I hope the Municipal Commissioners may think it even yet not too late to give Dr. Chevers' proposal a fuller consideration. I suspect the European community will always use the Maidan water in preference to any that can be supplied from the river."

It is to be regretted that the proposal of Dr. Chevers, supported as it is by a Chemist of Dr. Macnamara's authority, has not received due consideration from the Justices. No allusion has been made to it in the Report of the Engineer, nor in the Proceedings of the Drainage Committee of the Justices.

The Committee deem it due to observe that the bulk of the rate-payers of the town are Hindus, and, knowing as they do the prejudices which exist among their orthodox countrymen to the use of "pipe-water," they submit it cannot be fair to adopt a system of Water-supply to



WORKS AT PULTA



**DIAGRAM.**

### Sieving proposed arrangement of Levels for Gravitation Works

which nine-tenths of the inhabitants will have religious objection, but for which they will, as a matter of course, be taxed. This objection would, however, be obviated by carrying out a system of tanks proposed above. The Committee need not repeat that the supply of water required for drainage works may be provided by the extension of the scheme already in operation in the town.

The Justices, it appears, hold out no encouragement to private enterprise for undertaking the works. They have endorsed the recommendation of the Water-supply Committee, the reasons of which have not been stated, "that the carrying out of the scheme ought not to be placed in the hands of any Water Company." The Committee do not see the propriety of this restriction. That it is far more economical in the end to have public works executed by a private Company than by the direct agency of the Government or the Municipality will, the Committee submit, scarcely admit of a serious doubt. If it be contended that a private Company always works with an eye to profit, there is a certainty of great economy in its operations, while the State or the Municipality is secured against any excess of expenditure above the amount of contract. This position is markedly illustrated by the Drainage works, the original estimate of which was Rupees 82,85,000, but the actual cost of which, it is feared, will reach four times that amount. There have not been any material modifications of the scheme, while large as has been the increase in the value of labour and materials, the enormous difference between the original estimate and the actual cost cannot, the Committee suspect, with propriety be wholly attributed to that cause.

The Committee accordingly request you will have the goodness to move His Honor the Lieutenant-Governor to take the above remarks and suggestions into consideration, and, in exercise of the powers vested in him by Section XXXIII. of Act VI. of 1863, to require the Justices to so modify their schemes as to admit of its execution without necessitating an increase of the burdens on the town beyond what has already been sanctioned by law for purposes of Water-supply, as well as of the opening of tanks and squares adverted to above. The Committee need hardly observe that they submit the foregoing observations with all the diffidence of unprofessional men, being confident that, whatever scheme may meet with His Honor's approval, His Honor will not overlook the paramount importance of combining economy with efficiency.

From the HON'BLE A. EDEN, Secretary to the Government of Bengal, to the Chairman of the Justices of the Peace for the Town of Calcutta,—(No. 1532, dated the 13th March 1865.)

I AM directed to acknowledge the receipt of the letter from the Secretary to the Justices of the Peace for the Town of Calcutta, No. 124, dated the 9th ultimo, with its enclosures, regarding a scheme for the supply of water to the Town of Calcutta prepared by Mr. Clark, the Engineer to the Justices, and adopted by them at their ordinary Meeting on the 6th idem.

2. In reply I am desired to state that, though fully disposed to admit that Mr. Clark's scheme deserves all that has been said in its favor by the Justices, the Lieutenant-Governor is unable to accord to it his sanction, under Section 33, Act VI. (B. C.) of 1863, until he is in possession

of the information necessary to enable him to judge whether the Town of Calcutta is able and willing to pay for so expensive and elaborate a system of Water-supply.

3. The Lieutenant-Governor cannot, on the very meagre information furnished in the Secretary's letter, sanction any such amendment of the Municipal Act as that which the Justices propose, the practical effect of which would be to place in the hands of the Justices the power of imposing a rate, without limit, sufficient to cover the interest on the outlay for the first construction of the works, their maintenance, depreciation of stock and plant, and the working expenses of the system. The charges under these heads for Mr. Clark's scheme,—even if the Estimates be not ex-

	Rupees.
* Interest on 50 lacs ...	3,00,000
Working expenses and petty repairs ...	2,00,000
Depreciation at 2 per cent. ...	1,00,000
Total ...	6,00,000

ceeded, which experience shews they are not at all unlikely to be,—will be no less than Rupees 6,00,000\*

per annum, or just about half the total revenue of the Municipality from all sources during the past year.

4. How the Municipality propose to provide any revenue at all for the Water-supply is not clear from the Report of the Justices, but apparently it is proposed to raise a certain amount by rate and to trust to the sale of water for the balance. What the Lieutenant-Governor wishes to know is the proportion of this annual charge of six lacs of Rupees which the Justices expect to raise by each of these methods respectively, and the data they have to warrant their incurring this heavy expense in reliance on a large sale of water. It is to be presumed that, before asking for the sanction of Government, a full and careful Estimate was prepared by the Justices of the number of persons who would purchase the water supplied by Mr. Clark's scheme, and the price they would be able to pay for it, and it is necessary that the Government also should have some reliable information on this point.

5. In considering the Estimate it should be borne in mind that the majority of the Native inhabitants of the town must be supplied with water without charge by means of tanks, which will have to be filled from the pipes. Amongst the more wealthy also, and even amongst the Europeans, it may be expected that there will be many who prefer to continue the use of water for drinking purposes from some tank from which they have for years been in the habit of obtaining their supply.

6. From such information as the Lieutenant-Governor has been able to obtain, His Honor believes that a water-rate at 2 per cent. will give a revenue of two lacs of Rupees at the outside, and for this rate if 680,000 gallons of water be supplied for watering the streets, and 1,320,000 for the free consumption of the poorer classes at four gallons per head, that is to say, for 330,000 souls, or three-fourths of the population of the city, 4,000,000 gallons of water remain to be sold at a rate which shall produce between 4 and 5 lacs of Rupees a year. The number of paying consumers necessary to ensure this revenue at the rate of thirty gallons per head will be 134,000, or the remaining one-fourth of the population, taking the charge for the water to be 3,000 gallons or 200 mussucks for the Rupee. I am to enquire